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EXPERIMENTAL AND PATHOLOGICAL STUDIES IN THE DEGENERATIVE TYPE OF ARTHRITIS *

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The term "degenerative arthritis" is employed infrequently by practitioners of medicine as compared with its synonyms "hypertrophic arthritis", "osteo-arthritis", "arthritis deformans", or "senile arthritis". Yet, if one attempts to translate the meaning of the various synonyms for degenerative arthritis or to study in detail the pathology of this type of joint disease, one cannot fail to appreciate that the term "degenerative arthritis" is the most appropriate designation because it portrays very accurately the primary pathological change observed. If the word "degenerative", when used in this connection, describes accurately the primary pathological change, it seems reasonable to conclude that "degenerative arthritis" should be the preferred terminology when speaking of this type of joint disease.

However, one might rightly contend that other intra-articular changes are observed in this type of joint disease. Such a contention is granted, but not without pointing out the fact that such intra-articular findings are secondary to the primary degenerative process. These changes are not only secondary, but usually represent an end stage of this particular pathological state. Translation of the various synonyms reveals that for the most part they refer only to these end-stage findings and not to the primary pathological alteration. For instance, hypertrophic arthritis is defined as a form of arthritis characterized by the hypertrophy of cartilage at the margins of joints, with subsequent ossification of this hypertrophied tissue. In other words, the term when so

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employed refers to the end-stage marginal lipping so frequently demonstrable by roentgenographic examination. This, however, is a late finding and is not demonstrable early in the disease. The term "osteoarthritis" is equally as inappropriate because it implies that the arthritic changes are confined solely to the bony structures. Furthermore, there is no implication as to the nature of the bony changes which will be encountered. The name "arthritis deformans" has been employed by some because marked joint deformity, such as Heberden's nodes, etc., appears late in the disease. Thus the term "arthritis deformans" refers only to the stage of the disease in which gross deformity is readily demonstrated and gives one no inkling as to the nature of the pathological process responsible for such deformity. Furthermore, it must be remembered that other types of arthritis eventually result in gross joint deformity. Of all the synonyms employed for degenerative arthritis, the term "senile arthritis" more nearly portrays the exact pathological state observed. However, one must appreciate that these involutional joint changes are often encountered in younger individuals who display none of the other involutional changes of senility. For this and other reasons, one must realize that there are other causes for such degenerative joint changes than senescence or physiological aging.

If we are to champion "degenerative arthritis" as the preferred terminology for this type of joint disease, we must next consider the evidence that it is primarily a degenerative disease, irrespective of cause. As classical a description of this type of arthritis as exists is that originally presented in the monograph by Nichols and Richardson [7]. Therefore, we present as accurate a summary of their original description of degenerative arthritis as is possible in the space allotted to it.

In degenerative arthritis, the earliest and primary change in the joints is a gradual and uneven degeneration of the hyaline cartilage of the articular surfaces. This is first detected as a fibrillation of the cartilaginous matrix, which generally begins near the articular surface and is associated with a disappearance of the spindle-celled perichondrium. As a result of this fibrillation, which takes place usually at right angles to the articular surface, the neighboring cartilage cells are set free and finally disintegrate and disappear. Also, the original smooth articular surface takes on a papillary appearance. At times this fibrillation is responsible for the freeing of minute masses of cartilage and fibrillated matrix. The depth to which this fibrillation extends varies. Sometimes it extends entirely through the cartilage down to the zone of provisional calcification * so that masses of cartilage may be peeled away, exposing either the zone of provisional calcification or the underlying bone to the attrition of joint motion. Occasionally, only a portion of the articular cartilage undergoes degeneration, fibrillation, and destruction. This leads to thinning of the

* We reserve the term "zone of provisional calcification" for the deepest layer of cartilage in growing bone. We prefer the term "calcified cartilage" for that layer of cartilage referred to by Nichols and Richardson as the "zone of provisional calcification".

cartilage over a circumscribed area. To meet this erosion and depression, an overgrowth occurs on the opposite joint surface. This is brought about by increased activity of the perichondrium. As a result, an irregular or somewhat toothed joint line is formed and, finally, with ultimate disappearance of the entire articular cartilage, the two bony surfaces are brought into contact. Since this change takes place gradually and is at first confined only to a portion of the joint, motion is continued with the result that the exposed bone undergoes marked thickening of the trabeculae and narrowing of the marrow spaces until an extremely dense bony structure has been produced. The friction of continued joint motion produces a high degree of polish on the exposed condensed bone which then acquires an appearance closely resembling ivory; hence the term "eburnation of bone".

While this process of fibrillation and destruction of cartilage with erosion is taking place in one portion of the joint and a corresponding overgrowth is occurring on the opposite joint surface, secondary changes in the joint may be produced. Changes in the shape of the joint surface may gradually, over a period of months or years, lead to more or less extensive subluxations. As a result, the amount of joint motion may be diminished or, in certain instances, the joint surfaces may become interlocked, producing "ankylosis by deformity". There is no true ankylosis in this type of joint disease. Common among these imperfectly understood secondary changes is an increased activity of the perichondrium at the periphery of the joint where the cartilage and capsule come together. This results in the new formation of cartilage which may be transformed into bone and thus causes an increase in the size of the bone end. As a rule this increase in circumference is not uniform, but is irregular and the contour is nodular, as exemplified by Heberden's node. Since this deposit of new bone is usually within the attachment of the joint capsule, it may in some cases lead to filling up of the original joint cavity, thus producing partial or complete dislocation.

As a rule, no great increase in the thickness of the joint capsules of these joints is observed, and, in many instances, the synovial membrane appears normal. However, in some cases, there is marked thickening of the synovial membrane with the production of papillary or pedunculated masses of connective tissue which may be converted by metaplasia into cartilage or bone or, in some cases, into fat tissue. Detachment of these pedunculated masses may give rise to loose bodies, the so called joint mice. The breaking off of an osteophyte is another cause of loose-body formation. As a rule, in this type of joint disease there is very little tendency for the synovial membrane to extend over the articular surfaces and in no case does fibrous ankylosis occur.

Nichols and Richardson in their monograph also call attention to the fact that in the early degenerative changes in the articular surfaces there is no evidence of inflammatory exudation.

Having presented the evidence of Nichols and Richardson that this

type of arthritis represents a true degenerative process, we can next inquire as to what factors are responsible for the maintenance and nutrition of normal articular cartilage and its ability to regenerate.

In order to evaluate the importance of apposition and weight-bearing, the following experiment was undertaken: Dogs' knee joints were disarticulated. The patellae and patellar ligaments were utilized in covering the denuded femoral articular ends. In each case, by careful closure of the synovial membrane and joint capsule, a fairly satisfactory sac, lined with synovia and enveloping the end of the femur, was obtained. These dogs were sacrificed twelve and twenty-eight weeks later. The femoral articular ends were very similar in appearance. Fine and coarse adhesions separated the space lined with synovia into numerous compartments containing synovial fluid. The articular cartilage was dull gray in color and showed numerous areas of partial atrophy and degeneration. Gross sections revealed marked atrophy of the subchondral bone. Microscopic examination corroborated this finding. The articular cartilage was greatly thinned out, showing depressed areas in which complete degeneration had occurred. The calcified zone of cartilage was reduced in thickness. In some sections, the articular cartilage was covered by a thin layer of fibroblasts which had originated at the perichondrial border. These findings suggest that apposition and weight-bearing of adjoining articular surfaces are of importance in the maintenance of normal articular cartilage.

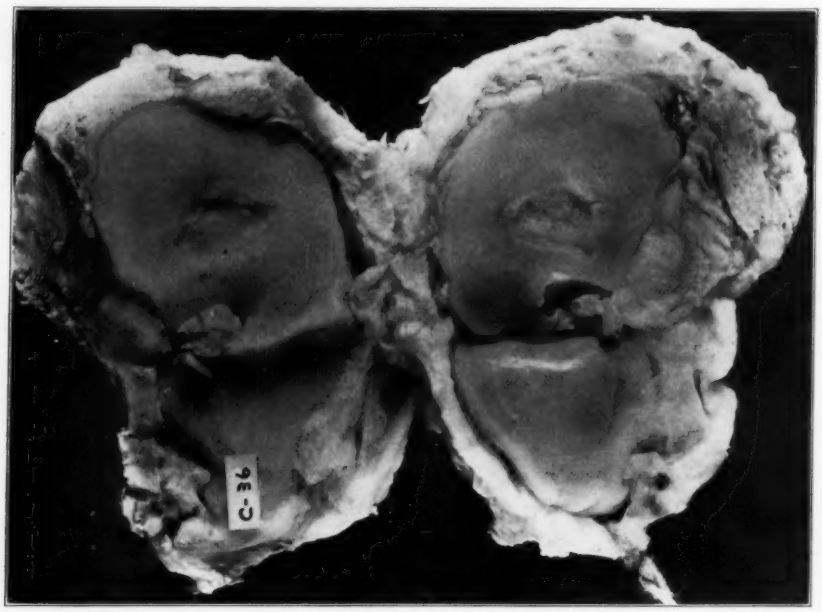


FIG. 1

Photograph (three-quarters natural size) of the opened carpometacarpal joint of a young beef steer, showing moderately well advanced degenerative lesions in the opposing articular surfaces of the medial condyle.

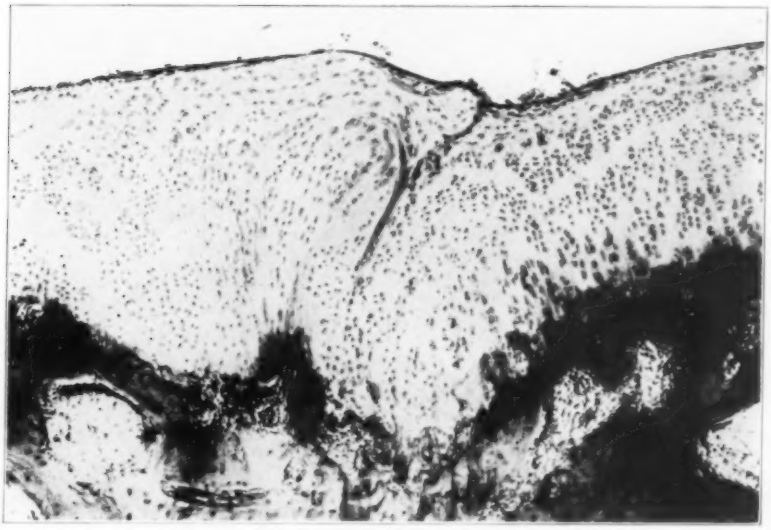


FIG. 2

Photomicrograph (× 65) of one of the earliest degenerative lesions observed in the carpometacarpal joints of cattle. The articular cartilage shows early fibrillation and splitting of the matrix, distortion of the columns of cells, and cellular proliferation near the articular surface. The calcified zone of cartilage directly beneath the surface lesion is depressed, thinned out, and completely disrupted in several areas.

The nutrition of cartilage must play an equally important rôle in the maintenance of normal cartilage and its ability to regenerate. The cartilage at the perichondrial margins probably receives its nourishment from the circulus articuli vasculosus of Hunter. As has been shown [3], it is in this region that articular cartilage shows the greatest ability to repair itself. The central portion of the articular cartilage is avascular and the exact source of its nourishment is unknown. It may be that it is derived solely from synovial fluid, or from serum water diffusing through from the subchondral-bone vessels, or a combination of the two. The ability of the central portion of articular cartilage to repair itself is at best very feeble and limited [3]. Reasoning teleologically, one might argue that this restricted source of nourishment is adequate explanation of the fact that articular cartilage is a tissue with a low metabolic rate. One might also reason *a priori* that with a limited nourishment, especially in the case of a specialized tissue such as articular cartilage in which the matrix is in great excess as compared to the cellular elements, the ability of cartilage to regenerate would at best be very feeble.

That such a state of affairs is true is readily demonstrated by two types of experimental study: (1) a systematic study of degenerative articular-cartilage lesions, occurring spontaneously in bovine joints [2]; and (2) a study of the repair of surgically created articular-cartilage defects in dogs [3].

In all cattle over two years of age, there occurred regularly an articu-

lar-cartilage defect on the opposing articular surfaces of the medial side of the metacarpal and carpal bones (Fig. 1). The earliest of these articular-cartilage defects were characterized by slightly depressed roughened areas which occurred in the concave surface of the medial articular cartilage. Microscopically, the earliest change noted was thinning of the layer of calcified cartilage. The roughened areas proved to be distorted and scattered groups of cartilage cells covered by fibroblasts. Associated with these changes there were frequently noted varying degrees of fibrillation of the cartilage matrix and distortion of the columns of cartilage cells (Fig. 2). In the slightly more advanced lesions, shallow depressions and definite thinning of the articular cartilage had occurred. In such instances, the calcified zone was markedly thinned, disrupted, or absent. The larger and deeper areas of degeneration in articular cartilage were sharply outlined by an irregular margin of overhanging cartilage (Fig. 3). The base of such defects extended into subchondral bone. Microscopic examination of such lesions revealed that the articular cartilage had completely disappeared in this sharply demarcated area of degeneration. Subchondral bone had disappeared in some instances for a depth six times the thickness of articular cartilage. At the margins of these defects, there occurred an abrupt change from normal hyaline

FIG. 3

Photomicrograph (× 76), showing the abrupt overhanging margin of a fully developed degenerative lesion in the articular surface of the carpal bone. Fibrous tissue lining the defect has extended only a short distance on the adjacent articular cartilage and there is little evidence of reparative activity. No noteworthy evidence of inflammation was observed in this joint.

FIG. 4

Photomicrograph (× 95) of a shallow and incompletely developed defect in the carpometacarpal joint of a young steer. The calcified zone of cartilage is broken in many places, thus permitting fibrous tissue to grow through from the subchondral-bone spaces and to line the base of the defect. Such fibrous tissue is converted into fibrocartilage or finally, in some instances, into atypical hyaline cartilage. This lesion showed evidence of more active reparative changes than were observed in any other lesion studied.

cartilage into fibrocartilage and fibrous tissue. The bases of the defects were lined by avascular fibrous tissue. This fibrous tissue was occasionally replaced by fat tissue. The underlying bone trabeculae showed evidence of atrophy and rearrangement; in one instance, definite crushing of the trabeculae was observed. The marrow spaces were filled with fat, but showed no evidence of fibrous-tissue proliferation. These lesions did not necessarily progress once they had developed. No important pathology was found in the synovial membranes of such joints. Such cartilage defects were not associated with other joint changes, nor were they the cause of such changes. What we wish to stress most of all is the fact that there never was more than minimal evidence of cartilage repair in any of these lesions (Fig. 4).

It is our belief that these progressive articular-cartilage defects are due to the repeated traumatization of the weakly constructed carpometacarpal articulations in an area where the underlying subchondral bone does not adequately support the articular cartilage. Such trauma to the metacarpal joint occurs each time the cow lies down or gets on to her feet from the recumbent position.

In order to study further the ability of articular cartilage to regenerate, surgically created defects on the weight-bearing portion of the femoral condyles and in the central portion of the patellar grooves of the knee joints of dogs were studied at intervals varying from four to twenty-eight weeks after such defects were made [3]. In certain instances, these defects

were made sufficiently deep to extend into the underlying subchondral bone.

The results of such experiments may be briefly summarized as follows:

1. In a few instances, no evidence of any type of cartilage repair was demonstrable.

2. Repair may take place by independent proliferation of original cartilage cells. Such proliferative activity of cartilage cells is greater in the deeper zones of articular cartilage. More active proliferation of cartilage cells is observed in lesions made on the weight-bearing surface of the femoral condyle or in lesions in which crevices exist, suggesting that the friction generated by movement of the patella over such defects may be inhibitory to repair in this manner. In no instance was repair complete at the end of twenty-eight weeks. In the majority of instances, the repairing tissue filled but a small portion of the defect crater.

3. Repair may take place by proliferation of vascular connective tissue from the perichondrial margins. In such instances, the vascular connective tissue invades the defect, and may pass through the stages of fibrous tissue, fibrocartilage, and an imperfect hyaline cartilage.

4. Repair of the defects which have extended into the subchondral bone proceeds in an orderly sequence. First there occurs an ingrowth of vascular connective tissue from the bone-marrow spaces, which subsequently becomes fibrocartilage and finally an imperfect hyaline cartilage. In this type of defect, one observes the most rapid and constant type of repair of the articular-cartilage crater. These later findings suggest that any denuded areas of articular cartilage, particularly the type of defect encountered in osteochondritis dissecans, might be expected to regenerate with this type of imperfect hyaline cartilage if, at the time of operation, the margins of the defect were shaved down to viable cartilage and if free communication with the underlying subchondral-bone spaces was established.

5. Comparative studies indicate that the repair of such surgically created defects in similar areas in the joint is no more rapid or complete in young puppies before closure of the epiphysis than it is in adult dogs.[6]

6. The presence of such surgical defects was not a cause of other important joint pathology.

7. The repair of articular cartilage is at best very feeble. Therefore, it would seem justifiable to conclude that, once cartilage destruction or degeneration has occurred, there is very little chance that any appreciable degree of repair will ever take place. This being the case, we can scarcely expect to cure this type of arthritis. The best we can hope for is to remove if possible all accelerating factors, such as obesity, displaced patellae, faulty mechanics, unusual use, or trauma, etc., to which the joint is constantly being subjected and thereby to arrest or slow up the process of wear and tear or degeneration.

At the time of operation on the knee joints of the dogs, displacement

of the patella was necessary in each case in order to create the surgical defect on the weight-bearing portion of the femoral condyle. Evidently this undue stretching of the patellar ligaments in such instances was the cause of the permanent patellar displacement observed postoperatively in a few of the dogs. Such displacement was toward the medial side of the joint so that the patella was in apposition with the medial epicondylar ridge of the femur. This anatomical derangement invariably caused marked intra-articular pathology, whereas, in the joints in which the patellae remained in their normal positions, such changes were not observed. [3]

The changes noted were similar to those of degenerative arthritis in man. The patellar cartilage showed varying degrees of atrophy and degeneration. In one instance, there was almost complete degeneration of the cartilage, with roughening and fragmentation of the underlying bone. On the inner side of the medial patellar ridge, where the patella had rested, there were areas of cartilage degeneration and atrophy. On the opposite patellar condyle, it was noted that marginal proliferation of the cartilage had occurred. In such instances, the margins were raised, scalloped, and nodular. Numerous blood vessels had grown in from the adjoining synovial membrane. Thus, the proliferative and degenerative changes in articular cartilage, together with subchondral-bone overgrowth similar to that seen in degenerative arthritis, had seemingly resulted in these joints from simple patellar displacement.

Because of these observations, further studies concerning the effects of patellar displacement were undertaken.[5] These experiments were carried out on rabbits in which the desired derangement can be produced without opening the joint space or otherwise injuring any of the joint structures. Gross and microscopic examination of these joints revealed that anatomical changes, similar to those of degenerative arthritis, occurred as early as four weeks after displacement of the patella. These changes progressed and became more marked in the experiments of longer duration. Marked lipping of the articular margins of the femur occurred. This was accompanied by degeneration of the original articular-cartilage surfaces and, in some instances, by eburnation of the denuded bone.

Evidence is also obtainable from the clinic which readily demonstrates that extensive intra-articular changes, indistinguishable from degenerative arthritis, occur at a much earlier age in individuals with displaced patellae. This anatomical derangement in older individuals is the cause of unusually extensive intra-articular changes of the degenerative type.

In a study [1, 4] designed to obtain an accurate visual picture, as well as a description of supposedly normal joints at various ages, we collected a series of knee joints from normal individuals who in so far as we could determine had never had symptoms of joint disease. These joints were obtained at necropsy. At least six knee joints, representing each decade from the first to the tenth, were collected. These joints were studied

roentgenographically, macroscopically, and microscopically. Such studies revealed that, with each succeeding decade in life beyond the second, the knee joint shows increasing pathological changes, degenerative in nature and confined for the most part to the articular surfaces. Often such changes are not demonstrable by x-ray examination. Arteriosclerosis does not appear to be an important etiological agent. The synovial membrane in such joints was either normal or showed only minimal changes. In such joints, there is little or no evidence of attempted repair. The earliest as well as the most advanced changes observed in these joints were identical in kind and indistinguishable from those commonly spoken of as characteristic of degenerative arthritis. From these studies, it is obvious that an individual may have extensive

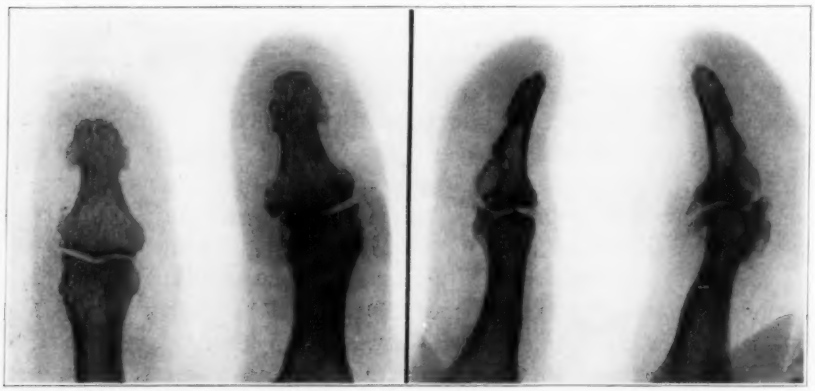


FIG. 5

Anteroposterior and lateral roentgenograms of the left and right thumbs of a seamstress who had worked for many years as a cutter. The constant and long-continued cutting with scissors resulted in a typical Heberden's node on the right thumb. These changes were minimal or absent in the left thumb and other phalangeal joints.

degenerative joint disease without having important symptoms referable to the joints. It is equally as apparent that roentgenographic examination usually does not give an accurate idea as to the extent of the intra-articular changes in this type of joint disease. If such extensive pathological changes can be demonstrated in individuals who deny having had joint symptoms, it is obvious that the surgeon should be very familiar with the appearance of joint structures at various ages, if he is to interpret properly the intra-articular changes which he encounters at the time of operation.

Since these changes were observed in the knee joints of individuals who supposedly never had had joint symptoms or joint disease, it seems logical to conclude that they represent the changes which result from daily use and increasing age.

Because of these findings, we undertook to determine what changes might take place in human joints subjected to unusual use or repeated

trauma. In such cases, the joint which had been subjected to constant use or unusual trauma was compared with the opposite joint which served as the normal control. For instance, a woman who had worked as a cutter in a tailoring establishment for fifteen years had a prominent Heberden's node on the thumb of the hand which was used in cutting, but no such nodosities were demonstrated on any of the other fingers (Fig. 5). Roentgenograms of another patient revealed extensive degenerative arthritic changes with loose-body formation in the right knee, whereas the left knee showed very minimal changes (Figs. 6 and 7). From her history, it was learned that this patient had operated a treadle machine for thirty years. In so doing, she was required to flex and extend her right knee hundreds of times each day, thereby subjecting this joint to unusual use for thirty years. Extensive changes, indistinguishable from advanced degenerative arthritis, were found when the knee was operated upon. Other patients demonstrated similar changes in joints which had been subjected to unusual trauma or excessive use.

From these observations, it would seem that one is justified in concluding that unusual use and repeated trauma are of themselves adequate causes for the production of extensive degenerative arthritic changes.

From these studies, it is apparent that extensive degenerative joint changes can take place as a result of the wear and tear of long continued daily use and increasing age, displaced patellae, unusual use, and repeated trauma. The changes resulting from these factors are evidently more marked in the case of articular cartilage than in other body tissues because of the limited ability of articular cartilage to regenerate. From clinical observations, we further appreciate that these changes can also be produced or, if present, hastened by increasing the load which the joint has to carry or by impairing the normal mechanics of the joint (Figs. 8 and 9). Such additional factors include obesity, knock knees, bow legs, fracture into the joint, poor alignment following fractures, severe pronation of the feet, etc. If such factors have been operative for a long time, evidence of degenerative joint changes will appear long before senescence has set in. In all probability, the type of cartilage that one inherits also governs in part, not only the age of onset of such joint changes, but also the rapidity with which such changes take place. Certainly there is no reason to doubt that the type of cartilage present must vary considerably from individual to individual. One might argue that there may be certain accelerating factors which could conceivably injure or impair articular cartilage and thus be responsible for the earlier development of such joint changes in certain individuals. All one can say in answer to such an argument is that to date there is no proof of the existence of such factors.

From the studies concerning the degenerative articular-cartilage lesions which occur spontaneously in bovine joints and the repair of cartilage in surgically created joint defects, it is apparent that the ability of articular cartilage to repair itself is at best feeble. Furthermore, little evidence of attempted repair was observed in the human joints showing

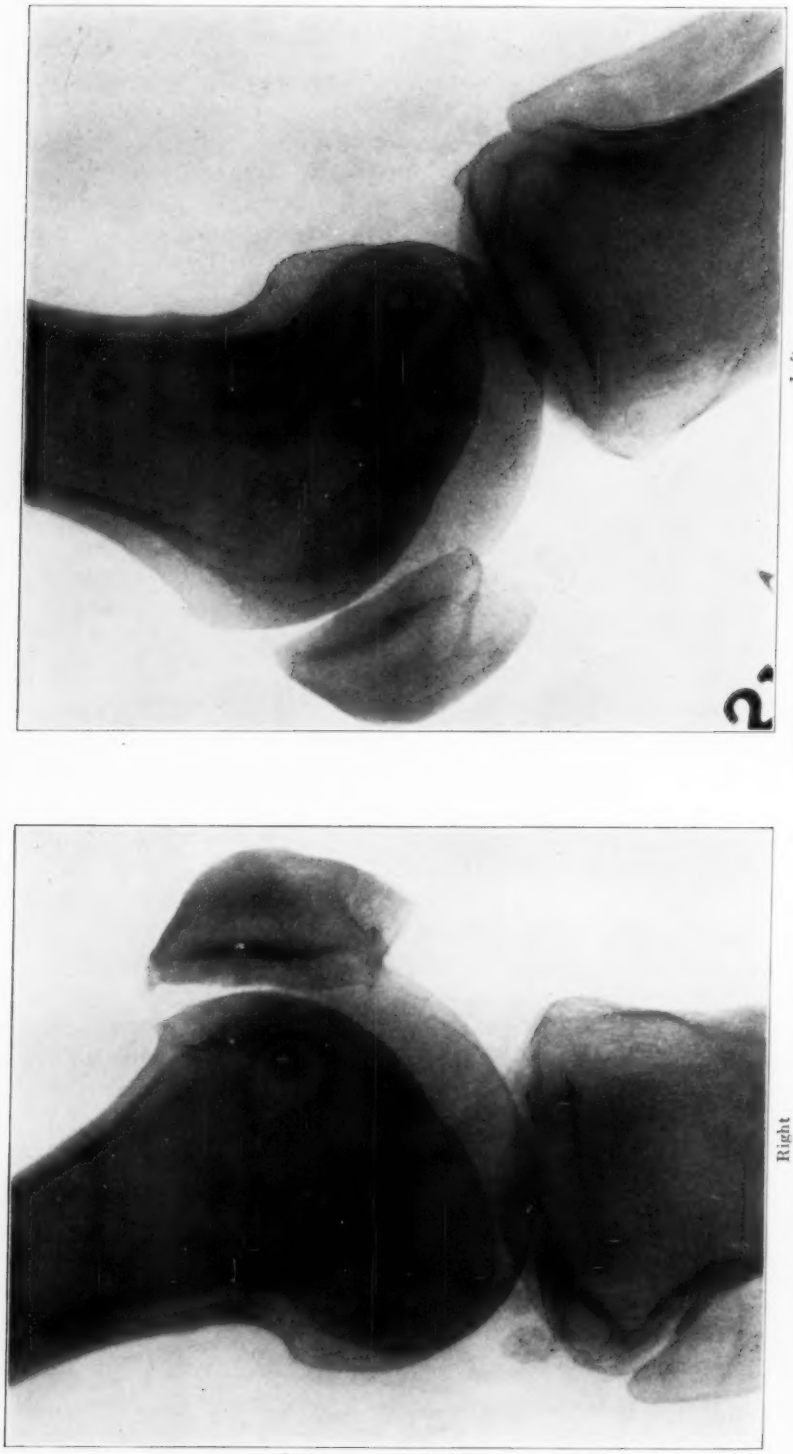
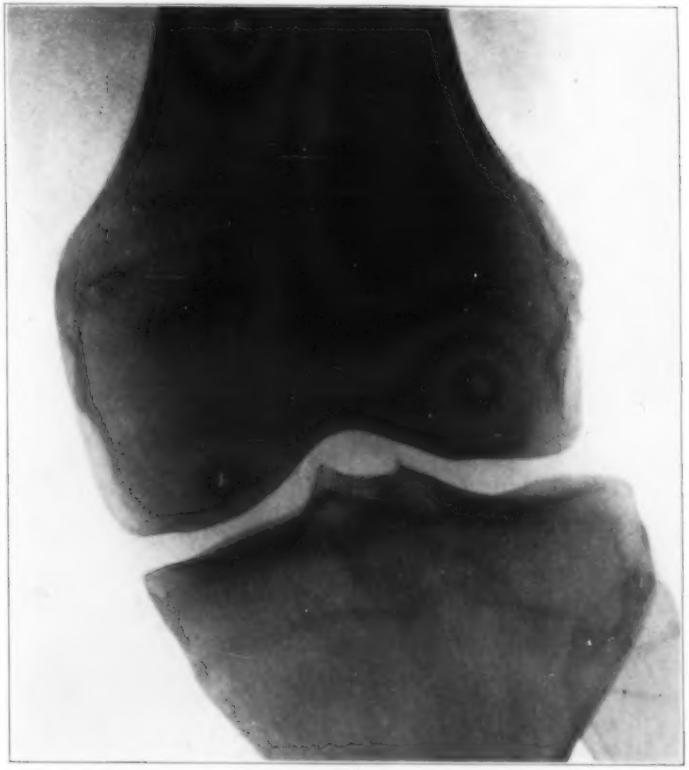


FIG. 6

Lateral roentgenograms of the right and left knee joints of a patient forty-seven years old. (See Fig. 7.)

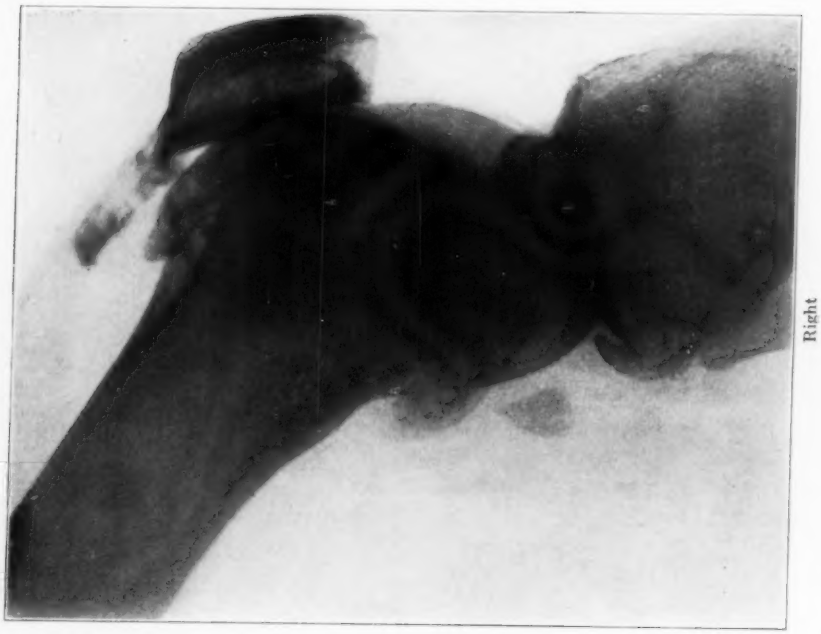
Right



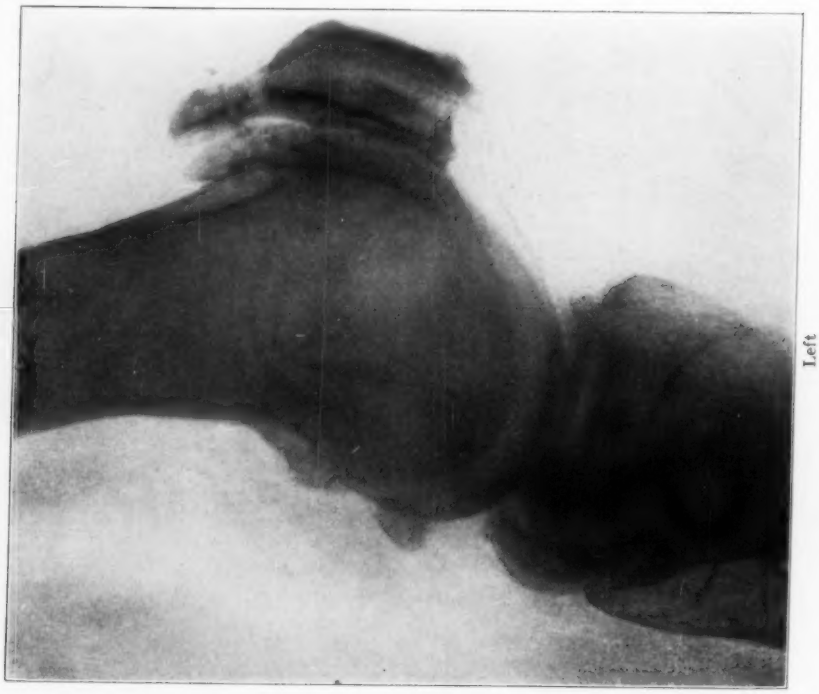
Left

FIG. 7

Anteroposterior roentgenograms of same patient as shown in Fig. 6. This woman had operated a punching machine in a shoe factory for thirty years. Her work had necessitated the intermittent flexion and extension of the right knee in displacing a foot treadle. The roentgenograms demonstrate marked hypertrophic changes and loose bodies in the right knee joint, whereas the left knee joint shows no more changes than one would expect to find in a woman of this age. At operation there was observed wide-spread degeneration of the articular surface of the patella and patellar surface of the femur with marginal lipping. Two loose bodies were removed.



Right



Left

FIG. 8

Lateral roentgenograms of the left and right knee joints of a woman fifty years of age. (See Fig. 9.)

Left

Right

FIG. 9

Anteroposterior roentgenograms of same patient as in Fig. 8. Very marked hypertrophic and degenerative changes are shown. There is evident marked lipping of the patellae, femora, and tibiae, as well as loose bodies in both knees. The loose bodies in the right knee were removed at operation. At that time it was noted that the articular surfaces showed advanced degenerative changes, including eburnation of bone. These excessive joint changes are attributed to long-standing obesity and genu valgum.

extensive degenerative changes. Thus it would seem fair to assume that little can be accomplished in the way of curing this type of joint lesion. However, if any causative or accentuating factor present can be corrected or done away with, it seems reasonable to believe that the process may be arrested or its rate of progress slowed up considerably.

The one point which we wish to stress is that in this type of joint disease the primary pathological change is one of degeneration, all other changes being secondary to the primary process. If such is the case, it seems reasonable to conclude that we should retain the word "degenerative" in this connection in preference to any of the other synonyms which are so frequently employed. This one word "degenerative" describes with great exactness the joint changes which occur and, therefore, if employed regularly to designate this type of joint disease, it would automatically portray the joint in question. In this same connection, one might rightly challenge the use of the word "arthritis" when speaking of this type of joint disease, because there is little or no evidence of inflammation in any of the structures of such joints. Some workers have suggested the term "osteo-arthrosis" for this type of joint disease. The name "osteo-arthrosis" seems a poor substitute for the previously employed terminology because, if literally translated, it means a joint full of bone. For the reasons previously given, we personally would prefer to speak of this type of joint change as the degenerative type of joint disease.

Similar degenerative joint changes are encountered in hemophilia*, gout, and Charcot's joint. In Charcot's joint, whether secondary to tabes dorsalis, syringomyelia, or leprosy, all the previously described changes are much more marked.

Because of the simultaneous existence of the degenerative type of joint disease and rheumatoid arthritis in the same individual, some workers have interpreted such findings as meaning that both diseases are due to infection. We cannot subscribe to this unitarian etiological theory. The intra-articular changes in these two diseases are in no way similar. It is true that an individual with degenerative joint changes may at some subsequent time develop rheumatoid arthritis. In such a case, the joint so affected will show on examination the degenerative changes as well as the inflammatory changes associated with rheumatoid arthritis. Similarly, rheumatoid arthritis with the characteristic periarticular swelling of the midphalangeal joints (spindle fingers) may develop in a person exhibiting Heberden's nodes and thus the telltale evidence of both diseases may be present. However, one must remember that evidence of inflammatory change is absent in an uncomplicated case of degenerative joint disease. Furthermore, rheumatoid arthritis may cause sufficient joint destruction so that the joint is no longer mechanically normal or stable. In consequence, the joint is subjected to increased trauma, as well as to wear and tear, and, as a result, degenerative joint changes ensue. How-

* We recognize the fact that the degenerative cartilage changes seen in hemophilic joints are only one phase of the entire pathological process.

ever, the examples just cited are not proof of the unitarian theory; they merely represent the existence of two diseases in the same individual.

If we are to interpret this type of joint disease as primarily a degenerative process, what bearing does this have on the symptomatology, prognosis, and treatment? At the time when the marginal-tissue proliferation is taking place, the periosteum may become elevated and, in consequence, pain may result. Once this proliferation of the marginal osteoid tissue ceases and this tissue becomes calcified, pain may no longer be present. Therefore, any treatment employed may be given credit for beneficial results, whereas the improvement may well be due to the natural evolution of such joint changes. This certainly is often the case with Heberden's nodes because they are frequently tender and painful in the earliest stages and later become quiescent. The other causes of pain in such joints are the altered mechanics and, occasionally, loose-body formation, or the impingement of a pedunculated synovial-membrane villus. In such instances surgery offers the only hope of alleviation of symptoms.

The most important feature of this disease as it concerns the patient is that he can be assured that he will never become a crippled invalid. Joint deformities, subluxations, and restricted motion do occur but such joints never go on to ankylosis.

In the treatment of this disease, we should all remember that it is primarily a degenerative disease, caused by the wear and tear of increasing age, unusual use, repeated trauma, faulty mechanics, loss of pain sensation, etc. There is no evidence favoring the various infectious, metabolic, or endocrine theories. Therefore, these patients should not be subjected to wholesale removal of foci, endless sera and vaccines, endocrine therapy, colonic irrigations, hyperpyrexia, weird dietary regimens, etc. True, a low-caloric diet will often result in sufficient weight reduction to bring about painless knees. However, in such instances, the weight reduction is the all-important factor and not any one special dietary feature. Weight reduction, if indicated, correction of faulty mechanics, and reassurance are the most important features in treating this disease. These patients must be reassured that they are not headed for crippledom and a life of invalidism.

CONCLUSIONS

1. We are of the opinion that degenerative arthritis is the result of the wear and tear of increasing age and repeated trauma which may be caused in a variety of ways and that it is not the result of an inflammatory process, metabolic disturbance, or endocrine dysfunction. The type of cartilage inherited may be responsible for the earlier onset and more extensive changes encountered in one individual as compared to another.

2. Because of the inability of articular cartilage to regenerate, we are of the opinion that one cannot cure this type of joint disease. Certain measures, however, can be instituted which will either arrest or slow the progress of the degenerative process.

3. Extensive degenerative joint change can be present in an individual without necessarily causing important joint symptoms.

4. If hypertrophic or degenerative arthritis is nothing more than degenerative joint changes due to the wear and tear of increasing age, unusual use, or repeated trauma, one has the right to challenge the correctness of the use of the word "arthritis" with reference to individuals with such joint changes. We, therefore, propose the name "degenerative joint disease" for this type of joint pathology.

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STREPTOCOCCIC DISSOCIATION IN THE PATHOGENESIS OF CHRONIC RHEUMATOID ARTHRITIS*

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Our earlier experimental work [7,8] demonstrated that the arthritic lesions produced in rabbits by mannite-fermenting streptococci were of striking similarity to the characteristic rheumatoid involvement in the human. The experimentally produced lesions were more acute at the onset, but, when this initial phase had subsided, the subsequent course was practically identical in both types of lesions.

Assuming these experimentally produced lesions to be pathologically identical with the naturally acquired human type, the crux of the test of streptococcic culpability seemed to rest on the possibility of demonstrating bacteria in human arthritic lesions with reasonable uniformity and regularity. We felt that the paucity of uniformly positive findings in biopsy material was due either to the actual absence of organisms or to the presence of growth-checking properties of joint and tissue fluids. Stained sections of affected joints were almost uniformly negative for bacteria. When cultured, rheumatic and arthritic nodules and lymph glands adjacent to joints gave more definite results in the hands of a number of investigators; and joint scrapings gave irregularly positive cultures that were considered inconclusive because of the relative inconstancy of the findings.**

For the past four years, the New York Orthopaedic Hospital and several other institutions have furnished us with biopsy material obtained from twenty-one joint operations on an equal number of patients. These cases were representative of the various types of more or less chronic arthritic lesions. Despite the fact that this number is admittedly too small for the forming of definite conclusions, we feel that certain aspects of our comparative clinical, pathological, and bacteriological studies on these cases are sufficiently interesting to warrant this preliminary report.

Clinically, the majority of the cases included in this study were diagnosed preoperatively as chronic proliferative arthritis in which the disease was more or less inactive, and surgery was resorted to in an attempt to restore at least part of the normal function of the joint through the removal of excessive synovial proliferation, freeing of the joint cavity from loose bodies, or relieving pain by curetting exostoses.

A careful survey of the histories revealed the fact that, during the more active phase of the disease, these patients had suffered either from rheumatoid arthritis in its pure form or from the type in which bone

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** Among these investigators are: Rosenow; Richards; Forkner, Shands, and Poston; Key; Cecil, Nicholls, and Stainsby; Poston; Margolis and Dorsey; Dawson, Olmstead, and Boots; and Gray, Fendrick, and Gowen.

change complicates the picture and exostoses form in addition to synovial proliferation. Because of the comparative inactivity of many of these lesions at the time of operation, and also on account of the rather misleading previous histories obtained, we felt that the best basis for classification could be evolved from a study of the activity of the arthritic processes as revealed by pathological sections rather than from the present clinical history. The criteria for determining activity were the degree of tissue reaction in terms of granulation, vascularization, perivascular infiltration, and histology of infiltrating and proliferating cells. Completely inactive, slightly active, moderately active, and highly active forms could thus be clearly differentiated.

TABLE I

A CLINICAL, PATHOLOGICAL, AND BACTERIOLOGICAL ANALYSIS OF TWENTY-ONE CASES OF OPERATIVE ARTHRITIS

Cases in Chronological Order	Clinical and Pathological Grouping of Material	Bacteriological Findings *				Pathological Findings **								
		Diphtheroid Bacilli	Micrococcus		Streptococcus	Connective Tissue			Synovial Tissue		Cellular Infiltration			
		Ordinary Pleomorphic	*Albus Aureus*	*Tetragenus Sarcina*	*Viridans Hemolyticus*	*Hyaline*	*Fibrous*	*Loose*	*Proliferation*	*Villus Processes*	*Polynuclear*	*Mononuclear*	*Plasma-Cell*
	GROUP I Inactive forms of:												
10 B. E.	Chronic atrophic hypertrophic	– –	– –	– –	– –	+ + +	+ +	+	+	+ +	–	–	-
18 N. U.	Chronic atrophic hypertrophic	– –	– –	– –	– –	–	+ + + +	–	–	–	–	–	-
	GROUP II Slightly active forms of:												
8 G. O.	Chronic atrophic hypertrophic	**+** –	– –	– –	– –	+	+ + +	–	–	+	–	–	-
9 G. R.	Chronic atrophic proliferative	**+** –	– –	– –	– –	–	+ + + +	–	–	–	–	–	-
	GROUP III Moderately active forms of:												
15 L. E.	Chronic atrophic proliferative	**+** –	**+** –	– –	– –	–	+ + + +	–	–	+	–	+	-
6 S. E.	Chronic atrophic proliferative	– **+**	+ –	– –	– –	+	+ + +	+ +	+	+	–	+ +	-
5 S. C.	Chronic atrophic proliferative	+ –	– **+**	– –	– –	+	+ + +	+ +	+ +	+ + +	–	+ +	-
4 U. L.	Chronic atrophic proliferative	+ **+**	**+** +	– –	– –	–	+ + +	+	+ +	+ +	+ +	+	-
1 S. A.	Chronic atrophic hypertrophic	– –	**+** –	– –	– –	–	+ + +	–	–	+	–	–	-
7 K. N.	Chronic atrophic hypertrophic	– –	**+** –	– –	– –	–	+ + +	–	–	–	–	–	-
19 B. A.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + +	+ +	+	+	–	–	-
17 R. O.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + +	+	+	+	–	+	-
21 R. A.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + +	+	+	+	–	+	+
3 R. U.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ +	+ + +	+ +	+ +	–	+ +	+ + +
16 B. R.	Chronic atrophic proliferative	– –	**+** –	– –	– –	+ +	+ +	+ + +	+ + +	+ +	+	+ +	+ +
	GROUP IV Active forms of:												
13 V. E.	Chronic tubere. proliferative												
20 E. D.	Chronic atrophic proliferative	– –	– –	– –	**+** –	+ + +	+ + +	+ + +	+ + +	+ + + +	–	+ + + +	+ + + +
2 Y. O.	Chronic atrophic proliferative	– –	– –	– –	**+** –	–	+ +	+ + + +	+ + + +	+ + + +	–	+ + + +	+ + + +
14 T. S.	Chronic atrophic degenerative	– –	– –	– –	– **+**	–	–	+ + + +	+ + + +	+ + + +	+ +	+ + + +	+ +
	GROUP V Subacute form of:												
11 M. C.	Tenosynovitis of the digital tendons	+ –	– –	**+ +**	– –	No tissue pathology							
	GROUP VI Acute form of:												
12 R. C.	Exudative metastatic arthritis	+ +	+ +	+ +	+ **+**	No tissue pathology							

* The bold face plus signs indicate the originally isolated micro-organism. The subcultural findings are denoted by the light plus signs.

** The degree of cellular reaction is indicated by the number of plus signs: + slight, + + + + very marked, etc. The minus sign indicates absence of tissue reaction.

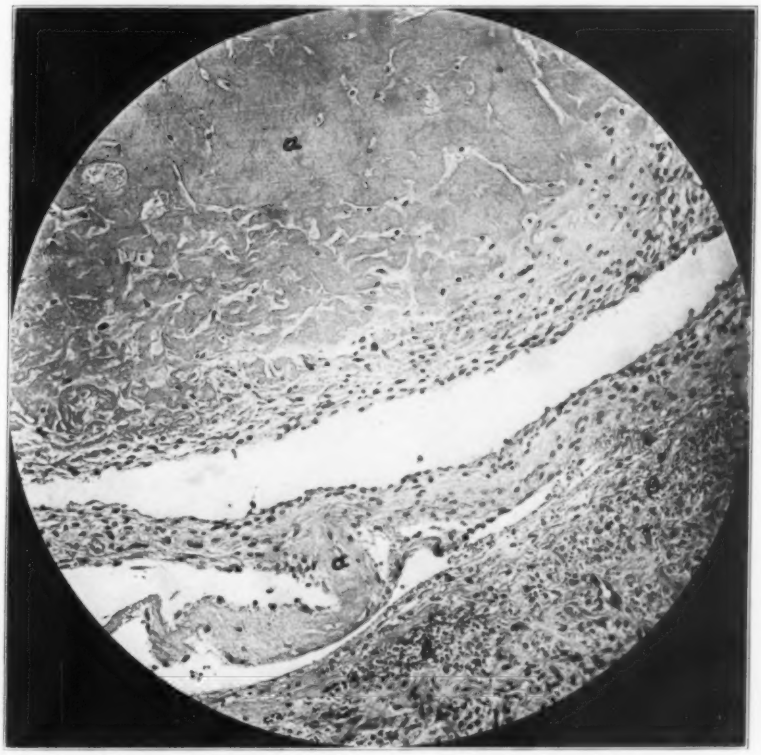

FIG. 1

Case 10. B. E. Hematoxylin-eosin stain (× 160).
Pathological features of an inactive, "residual" arthritis as classified in the table under Group I, showing:
a: Progressive hyalinization of the connective tissues of synovia and villus processes.
b: Remains of old lymphocytic infiltration in the sclerotic connective tissue of synovia.

In addition to the chronic arthritides, we were able to study one case of subacute tenosynovitis of the phalangeal extensor tendons and one case of acute metastatic arthritis of the elbow complicating a mastoiditis. Classification thus based on tissue reactivity showed an enlightening comparison between the activity of the process and the bacteriological findings (Table I).

Using our previously described technique for tissue culture[8], we found that avascular tissues were invariably negative bacteriologically. Cartilage and bony or villous fragments, loose in the joint cavity as rice bodies, were uniformly sterile. Since the growth and propagation of micro-organisms depend on the constant replenishment of nutrient material, tissue with a terminal blood supply—such as the vascularized synovia, the bone marrow, and the haversian system—should be the best suited for positive cultures. Such was found to be the case in the human as well as in the rabbit.

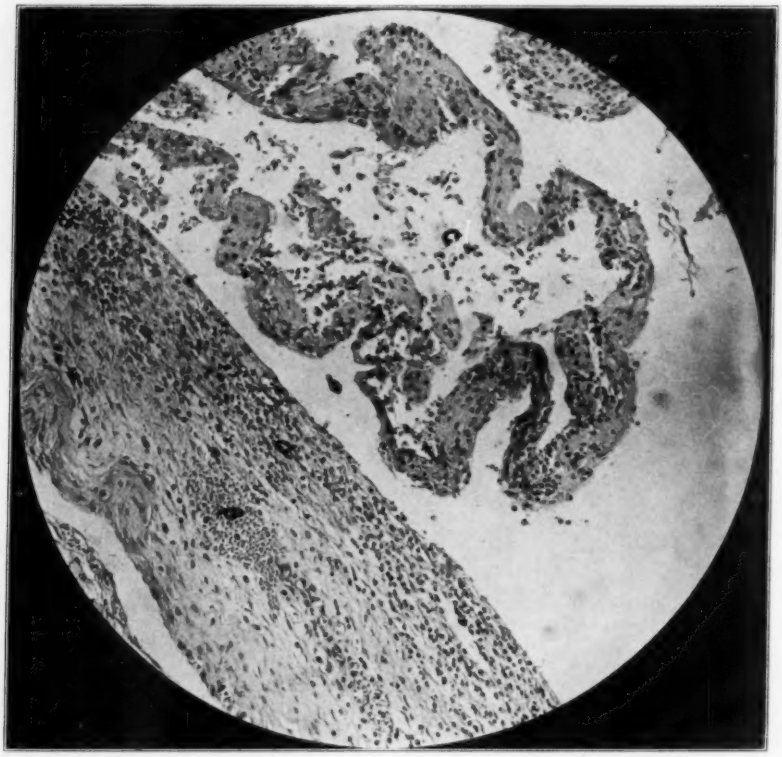

FIG. 2

Case 4. U. L. Hematoxylin-eosin stain (× 160).
Pathological features of a moderately active case as classified in the table under Group III, showing:
a: Low-grade cellular activity of the connective tissue of synovia.
b: Small collections of lymphocytic infiltration.
c: Moderately sized villus processes with the same degree of cellular activity.

The bacteriological, pathological, and clinical findings are given in Table I. The cases are grouped in series according to the activity of the arthritic process.

GROUPS I AND II

These four cases represent almost, if not completely, inactive forms of "residual" arthritis which, due to the passage of time, previous treatment, or natural immunity, has become quiescent with only residual manifestations of a mechanical nature for which the patients have sought relief. Two patients (Cases 9 and 10) were operated on for the removal of loose bodies in the joint cavity (the knee) and the other two patients (Cases 8 and 18) had curettage of spurs and exostoses.

Pathologically, the synovia was either completely fibrotic or partly degenerated into hyaline tissue. Occasionally, slight connective-tissue proliferation of the synovial membrane could be noticed, but there was no evidence of lymphocytic or plasma-cell infiltration. Figure 1 (Case 10) is

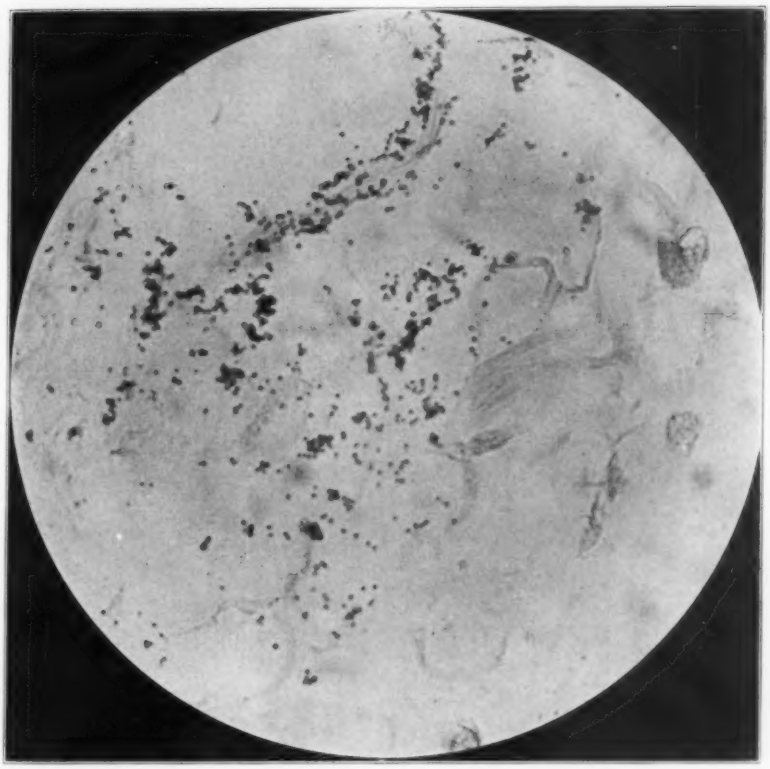

FIG. 3

Case 16. B. R. Gram stain (× 900).
Demonstration of staphylococci in synovia by the tissue-culture method.

representative of this group. Bacteriologically, the tissues either were sterile (Cases 10 and 18) or showed diphtheroid bacilli (Cases 8 and 9).

GROUP III

This group, which represents the moderately active phase of chronic proliferative arthritis, clinically, at least, is not homogeneous. A careful survey based on anamnesis would subdivide it into three groups. In Cases 4, 5, 16, and 19, the patients were chronic arthritics in whom the disease had been at a stage of quiescence similar to that of the preceding two groups, but their symptomatology had been intensified by trauma such as a blow, fall, or similar injury which had caused an exacerbation of pain or disability. Surgical intervention was justified as a corrective means for symptomatic relief. In Cases 1, 5, 17, and 21, torn internal semilunar cartilages were removed for the same reason, and in Cases 1, 3, 6, and 7, redundant synovial tissues had to be eliminated to restore part of the function of the joint. In the majority of these cases operations were performed on either one or both knees to overcome mechanical interference with function, while other joints such as wrists and ankles were

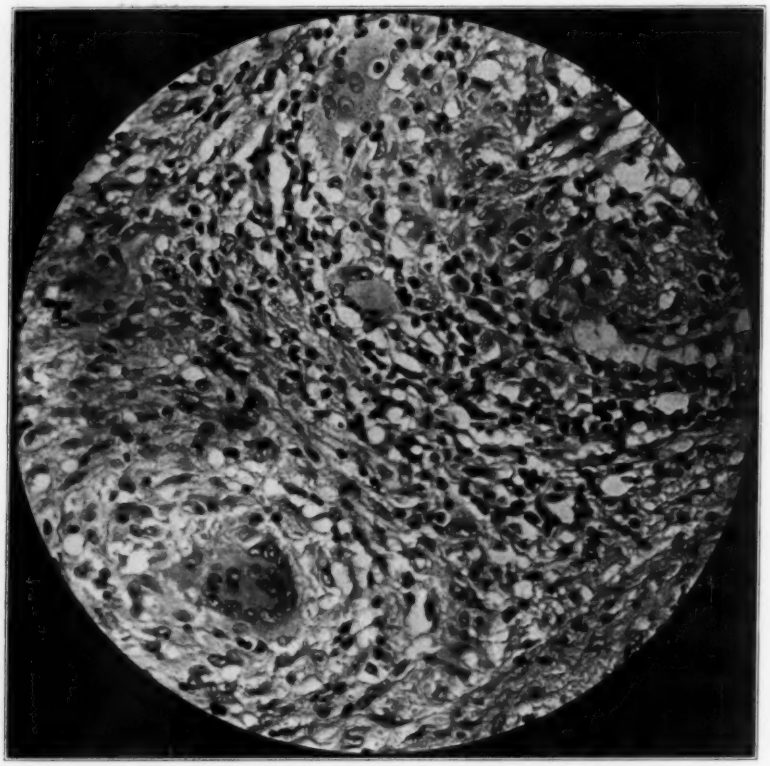

FIG. 4

Case 13. V. E. Hematoxylin-eosin stain (× 320).
A case of chronic tuberculosis of the knee joint with typical giant-cell formation.

quiescent or inactive. This particular group of patients had been afflicted for an average of three years by a true rheumatoid arthritis with superimposed villous overgrowths and exostoses, necessitating operative interference. This condition was demonstrated particularly well in Cases 1, 3, 6, and 7.

With slight variations in each case, the pathological picture was that of a chronic, low-grade, exudative-proliferative process. It was characterized by moderate thickening of the synovia, the formation of villous processes, and low-grade proliferation of these processes with young connective-tissue cells. The synovial parenchyma was moderately vascularized and slightly infiltrated with lymphocytic cells. In the main, this infiltration was diffuse, but occasionally it appeared to be perivascular. Plasma-cell infiltration, on the whole, was absent except in two cases (Cases 3 and 16), and, in these, it was not in any way an outstanding feature. Figure 2 (Case 4) is representative of this group.

Bacteriologically, in seven of a total of eleven cases, we grew micrococci similar to the staphylococcus albus. In the remaining four, there was a mixed staphylococcoid and diphtheroid growth. Although clini-

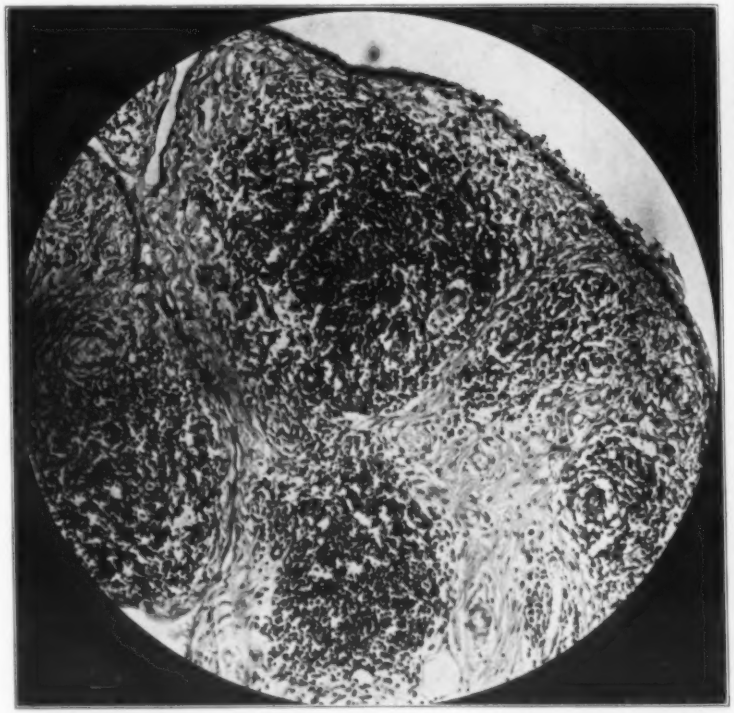

FIG. 5-A

Case 14. T. S. Hematoxylin-eosin stain (× 150).
Pathological features of an active form of arthritis as classified in the table under Group IV, showing actively proliferating and highly vascularized synovial tissues, infiltrated profusely with mononuclear cells.

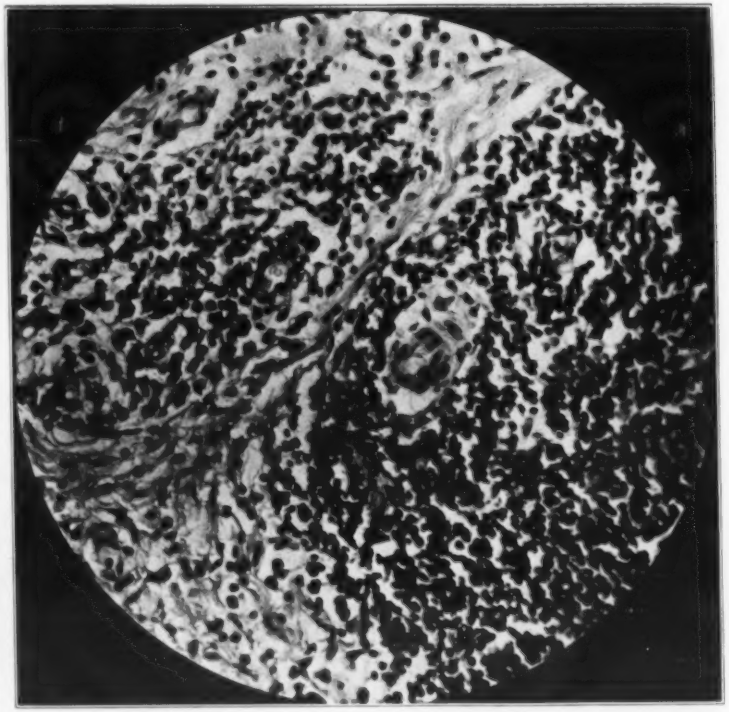

FIG. 5-B

Case 14. T. S. Hematoxylin-eosin stain (× 300).
This is a higher magnification of Fig. 5-A to bring out the histology of cellular infiltration. Note the perivascular distribution of lymphocytic cells and the activity of plasma cells in the synovial parenchyma. Note also the marked degree of endarterial proliferation of the intimal layer.

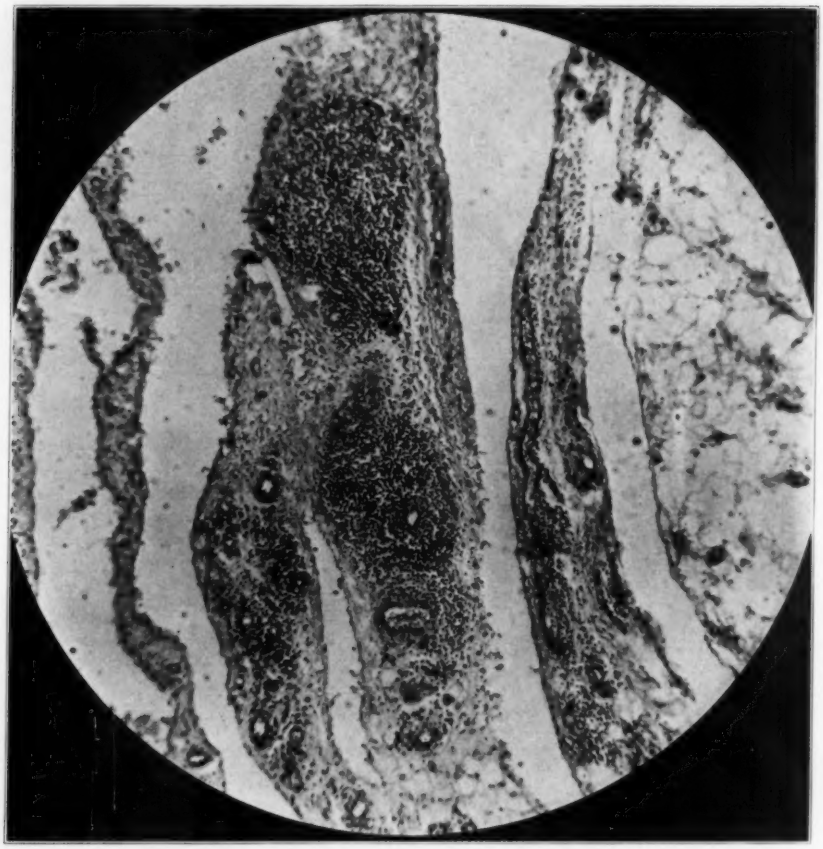

FIG. 6

Case 20. E. D. Hematoxylin-eosin stain (× 180).
Another active case belonging to Group IV, showing extensive villus overgrowths, marked vascularization, and perivascular lymphocytic infiltration.

cally all eleven cases were grouped together as moderately active, the mixed bacterial types (Cases 4, 5, 6, and 15) could be differentiated pathologically by the absence of plasma-cell infiltration. Whether or not this was a chance occurrence it is difficult to decide definitely, as the number of cases is inadequate. However, in view of the relatively simple pathology of the diphtheroid-positive group (Group II), the fact that this group was the closest approach to the culturally sterile group (Group I), and also in consideration of the fact that we found the diphtheroid phase to be the last in the course of an infection, as will be developed later, we feel that it is more than a mere coincidence. Figure 3 (Case 16) is a demonstration of staphylococcic forms in the synovial tissue.

GROUP IV

Of the four cases classified as active forms of chronic rheumatoid arthritis associated with marked proliferative changes, Case 13 did not

properly belong to this study, for, although originally diagnosed as chronic proliferative arthritis of unknown etiology, postoperative pathological studies disclosed its tuberculous origin (Fig. 4). However, such an analogy with cases of rheumatoid arthritis was shown as to warrant its inclusion. The remaining three cases could be very easily differentiated from the preceding groups by the intense lymphocyte and plasma-cell infiltration of the loose connective synovial-tissue network, which was highly vascularized and crowded with villous processes. The synovial capillaries, although mostly patent, had been narrowed considerably by definite proliferation of the intimal layer. These changes can be seen in the photomicrographs, Figures 5-A, 5-B, and 6.

The bacteriology of this group was similar to our previous cultural findings in the experimental arthritis of rabbits,—namely, mannite-fermenting streptococci: a streptococcus viridans in Cases 2 and 20 and a streptococcus hemolyticus in Case 14. In Case 13, the tissue from the tuberculous knee was sterile, as would naturally be expected. Figures 7-A and 7-B demonstrate the distribution of streptococci in the synovial tissue.

Before we take up the subacute and acute forms of arthritis (Cases 11 and 12), we will discuss these seemingly unrelated bacteriological findings in chronic arthritic tissues and their bearing on the bacteriology of the acute forms.

DISCUSSION OF BACTERIOLOGICAL FINDINGS

When we commenced this particular investigation four years ago, we were guided by our success in uniformly demonstrating streptococci in the cultured joint tissues of rabbits in which typical rheumatoid arthritis had been produced by the intravenous injection of arthrotropic streptococci isolated from the blood stream of human chronic arthritics. Our experience with human arthritic tissues seemed very discouraging, for, out of a total of nineteen more or less chronic arthritic tissues which were cultured, only three were positive for streptococci; the remainder either were sterile or showed only staphylococcoid forms and diphtheroid bacilli.

The negative cultural results in totally inactive forms of arthritis, such as the first group of cases, were not at all unexpected, but the appearance of diphtheroid bacilli in the slightly active forms and staphylococci, either alone or in association with diphtheroid bacilli, in the moderately active forms could not easily be accounted for. Should we consider them as contaminations when every possible precaution was taken to eliminate this source of infection? Or, assuming that they were tissue-invading organisms, should we attribute to them pathological significance?

We felt that they were not contaminations, but, for reasons easily understood, it was difficult to control this work with normal joint tissues of human origin. Nevertheless, we had the opportunity of culturing the digital joints of three stillborn babies and the biopsy material obtained from two bone punctures for blood-dyscrasia studies. In all five cases, the tissues cultured were sterile. Our experience with the joint tissues

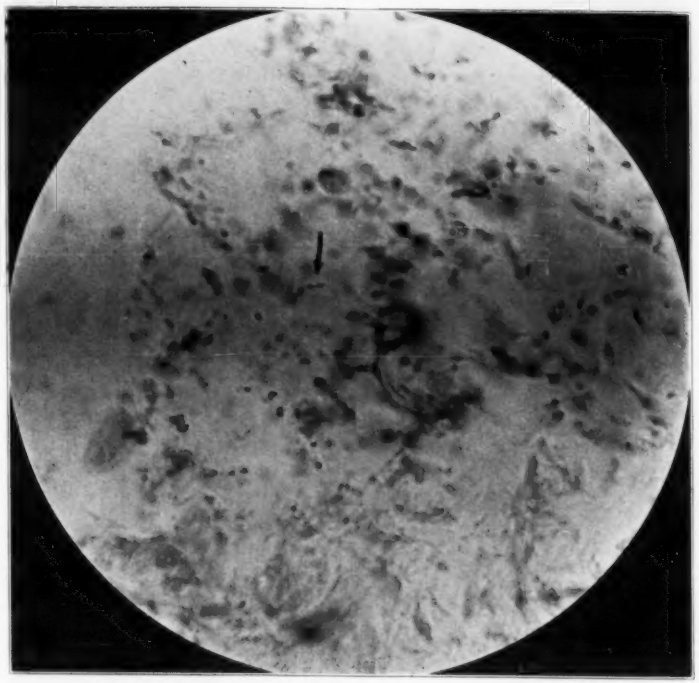

FIG. 7-A

Case 2. Y. O. Gram stain (× 1,280).
Demonstration of diplococci with the typical morphology of streptococcus faecalis in synovial tissue by the tissue-culture method.

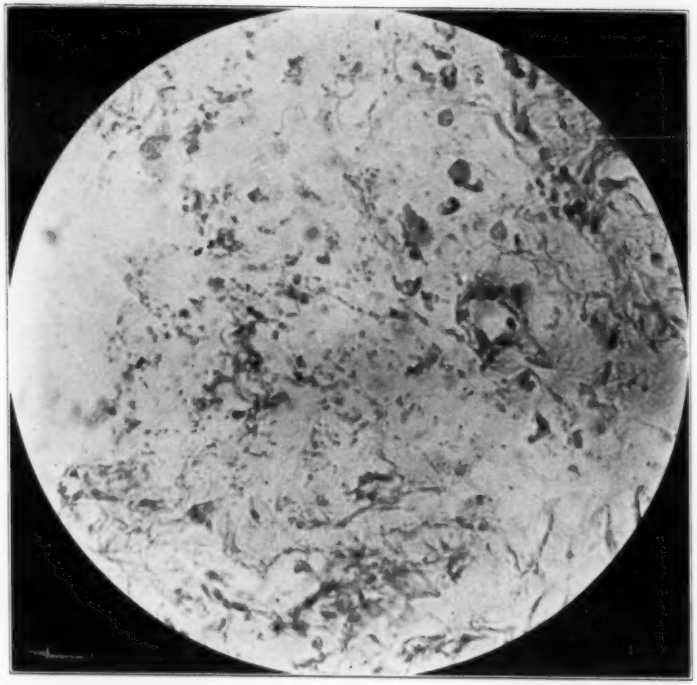

FIG. 7-B

Case 2. Y. O. Gram stain (× 800).
Same as Fig. 7-A, showing streptococci in ordinary chains.

from normal animals, which we have examined in sufficient numbers, has been that, with due precaution of asepsis, such tissues were invariably sterile.

To determine whether the non-streptococcic findings had any pathogenic potentialities, we injected these cultures into rabbits. All diphtheroid forms and the majority of staphylococcic forms could be given in massive doses without eliciting any pathology. Some of the staphylococcic forms were mildy pathogenic, but in no instance could we discover an arthrotropic selectivity such as was the case with mannite-fermenting streptococci. We noticed, however, that normal rabbits injected with such diphtheroid organisms became highly susceptible to arthritic lesions from subsequent injections of arthrotropic mannite-fermenting streptococci (streptococcus infrequens).

GROUPS V AND VI

In the following two cases of acute arthritis we had what seemed to be a clue to unravel through the labyrinth of the complicated bacteriology of human arthritic lesions.

CASE 11. M. C., a man, aged thirty-five, had a subacute form of tenosynovitis of the extensor tendons of the third and fourth digits, of two months' duration. The gross pathology was that of inflamed synovial tissue. As the tissue was too small for section, the whole of it was dropped in bouillon and cultured. The stained smear of the twenty-four-hour culture showed a scant growth of pleomorphic diphtheroid bacilli, but that of the forty-eight-hour culture showed micrococci in tetrads (micrococcus tetragenus). In subcultures on solid blood media, we differentiated certain dry, lemon-yellow *R* colonies in large heaped-up coccic blocks and cubes, which were identified as sarcina flava. We will not go further into the bacteriology of this case as another acute case of arthritis (Case 12), studied completely from its onset, gives ample opportunity for development in detail of these unexpected findings.

CASE 12. R. C., a girl, seven years old, suffered from an acute form of arthritis of the right elbow. This was metastatic in origin and occurred in the course of a mannite-fermenting streptococcus hemolyticus (infrequens) mastoid infection complicated by septicaemia and sinus and jugular thromboses. No studies of pathological sections were possible, as the joint was simply incised and drained. The culture of the slightly purulent serosanguineous exudate gave a mannite-fermenting hemolytic streptococcus (Fig. 8) in all respects identical with the organism isolated from the original mastoid lesion, thus substantiating the metastatic nature of the elbow involvement. In subcultures for four successive generations, we did not see any morphological or biological deviation from the characteristics of the original type. Beginning with the fifth generation, we noticed the appearance of pleomorphic diphtheroid bacillary forms (Fig. 9) in bouillon media. Then, in the subcultures on solid blood-agar media, we isolated the typical lemon-yellow *R* colonies of sarcinae (Fig. 10), similar to those isolated in Case 11.

The type of sarcinae with which we were dealing was highly unstable in morphological and biological characteristics, readily dissociating into apparently unrelated bacillary and coccic forms, and reverting to the original streptococcus hemolyticus and even to the streptococcus viridans through the diphtheroid-bacillary phase and to staphylococcus aureus and finally staphylococcus albus through the micrococcus-tetragenus phase. We elaborated a life cycle of the arthrotropic streptococcus infrequens through its various phases of dissociation, as shown in Figure 12. Details

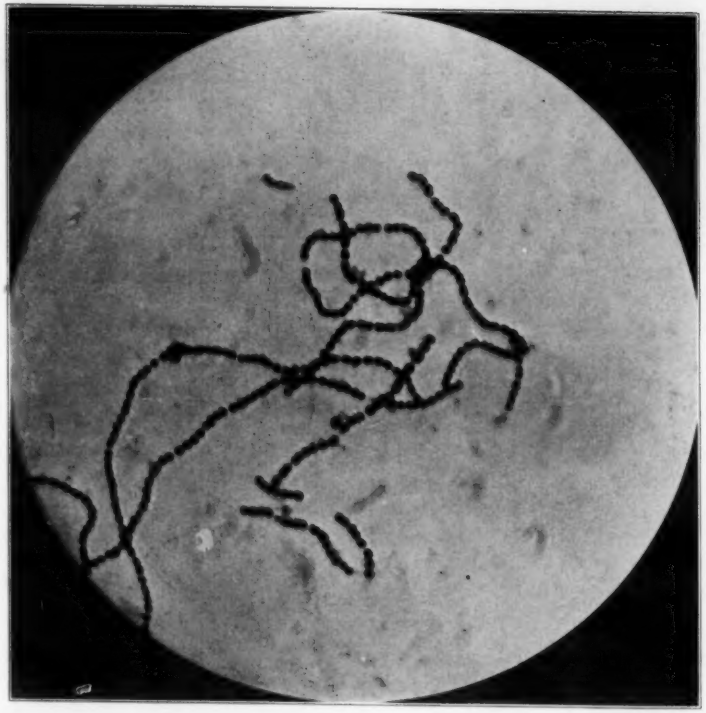

FIG. 8

Case 12. R. C. Gram stain (× 1,200).
The original streptococcus hemolyticus infrequens as isolated from the elbow joint on May 13, 1933.

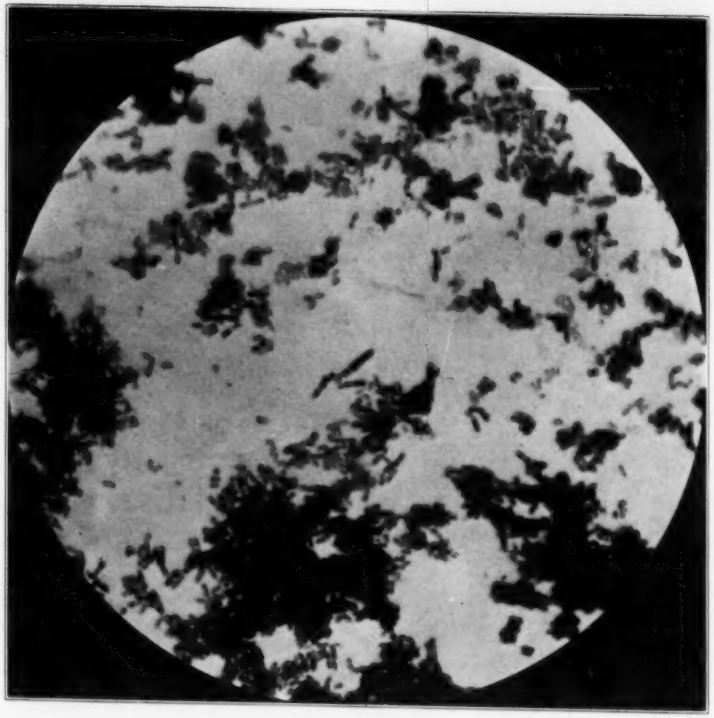

FIG. 9

Case 12. R. C. Gram stain (× 1,200).
The pleomorphic-diphtheroid phase appearing on May 20, 1933 in the pellicle of the bouillon culture of the fifth generation.

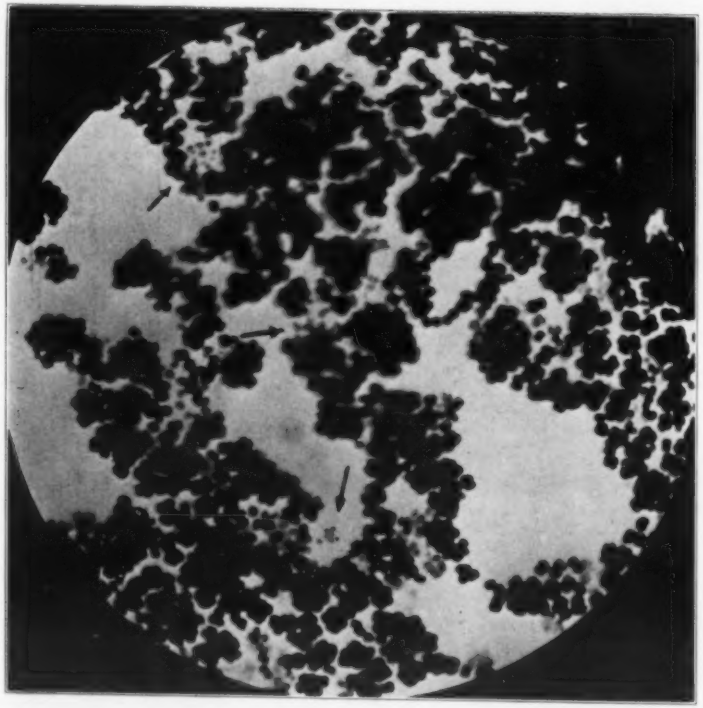

FIG. 10

Case 12. R. C. Gram stain (× 1,200).
The sarcinic phase succeeding the pleomorphic-diphtheroid phase within twenty-four hours. Note the minute, pale, granular masses between the sarcinic blocks as indicated by the arrows. Their actual size is about three-eighths of what it appears in the photomicrograph, due to the difficulty of focusing on bodies of different dimensional values.

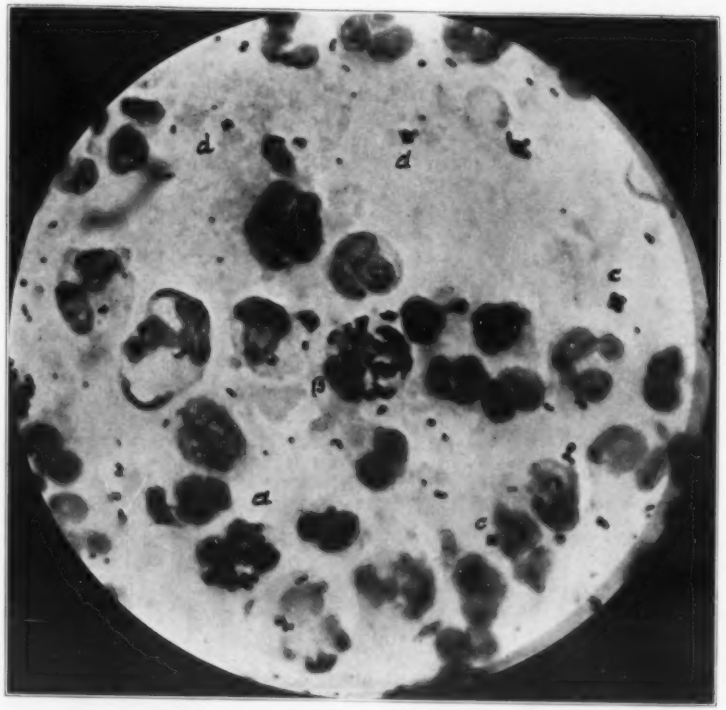

FIG. 11

Case 12. R. C. Gram stain (× 1,200).
Direct smear of joint exudate taken on June 17, 1933:
a: Pus cell showing phagocytosis of staphylococci.
b: Pus cell showing phagocytosis of diphtheroid bacilli.
c and *d:* Micrococcus tetragenus and diphtheroid bacilli free in joint fluid.

FIG. 12

The life cycle of a streptococcus hemolyticus isolated from Case 12.

of the bacteriological findings in these two cases, with their intricate serological interrelationships, will be given in a separate article.

COMMENTS

With due regard for the possibility of dealing with symbiotic colonies or even accidental contaminations, we might here emphatically state that all precautions were taken to eliminate such sources of error. It would, indeed, be even more difficult to account reasonably for so many widely different variations on the hypothesis of symbiosis, multiple infection, or even contamination.*

A further proof that, in obtaining these dissociants, we were not dealing with symbiotic life or accidental contaminations, but were actually bringing about *in vitro* what certain biological and immunological factors in the system of the host were working for *in vivo*, was found in the information obtained from the follow-up studies made in Case 12 of the progress, retrogression, and ultimate fate of this particular arthritic infection.

* Mellon, using the single-cell method in his research on the life cycle of tubercle bacillus, found that diphtheroid, micrococcic, and tetragenous forms invariably entered the picture.

In vitro, the time intervening between the streptococcic and sarcinic phases was eight days, May 13, 1933 to May 21, 1933. Final stabilization of the various dissociants (mutation forms), such as staphylococcus albus and diphtheroid bacillus, occurred in approximately one month, May 13, 1933 to June 17, 1933. The patient was discharged with a partially ankylosed and draining elbow joint on June 4, 1933. On her second visit for dressing, June 17, 1933, a thin, purulent discharge was still draining from the joint cavity. At this time, after carefully cleaning the skin area, we introduced a sterile platinum loop into the joint cavity and, from the material thus obtained, both inoculated a broth and took a direct smear. A photomicrograph of the stained direct smear (Fig. 11) showed a moderate number of pus cells and a few epithelial cells. The pus cells, as demonstrated in the photomicrograph, show a selective phagocytosis, some for staphylococci and others for diphtheroid bacilli. Among the freely floating bacteria, we could also detect a few tetragenous forms. The cultures yielded staphylococcus albus and diphtheroid bacilli. It may be a mere coincidence, but the fact remains that the time interval for the final stabilization of the changing flora into staphylococcus and diphtheroid bacilli, was the same *in vitro* and *in vivo*.

SUMMARY AND CONCLUSIONS

The evidence outlined would indicate that chronic rheumatoid arthritis may well be the result of a multiple mutant infection. The hypothesis is in line with the clinical course of the disease which, at the onset, may have all the earmarks of an acute infection (the streptococcic phase) before lapsing into the usual chronic form. Remissions, separated by shorter or longer periods of intermission, may be the clinical manifestations of the intricate immunological relationship of the streptococcic-dissociation forms,—the micrococcic-diphtheroid phase.

Up to two years ago, we could not satisfactorily explain why the serum of arthritic patients frequently reacted to a variety of apparently unrelated micro-organisms. The percentage of staphylococcic fixations in our records has always been high. Others have reported a variety of agglutinins for streptococcus hemolyticus as well as streptococcus viridans, for pneumococci and staphylococci.[1,3]

If we were actually dealing with a specific, immutable micro-organism with stable immunogenic properties, the course of the disease should not deviate from that of other acute infections,—that is, recovery, if the system is able to use its reactive defensive forces effectively, or death, in case it is overwhelmed by the extreme virulence of the invading organism. But if we have a streptococcus capable of dissociating into microbic forms that are less resistant to the immune mechanism, we feel that the natural tendency of the host would be to encourage such a metamorphosis. The bacteriological records of the twenty-one cases outlined support this hypothesis,—the active forms always yielding streptococci; the

moderately active, micrococci, either alone or with diphtheroid bacilli; the less active, diphtheroid bacilli; and, finally, the inactive or sclerotic forms being culturally sterile.

In concluding, we feel that, through a clear understanding of the mechanism of the immunological processes to which the human system resorts in bringing on these bacterial metamorphoses, we may some day have the main basis of a rational therapy for such chronic ailments.

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THE EFFECT OF LUMBAR SYMPATHECTOMY UPON THE GROWTH OF LEGS PARALYZED BY ANTERIOR POLIOMYELITIS *

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In 1930, one of us (R.I.H.) reported the effect of lumbar sympathectomy upon the growth of a lower extremity which was short as the result of a previous attack of anterior poliomyelitis. The patient was a girl, ten years of age, who eight years previously had passed through an attack of infantile paralysis which involved her left leg. There was an extensive paralysis of mild degree of many muscles in the leg. Shortness was the most conspicuous deformity. At the time of operation, it amounted to one and a half inches and necessitated the use of a raised boot. In the two years which followed operation, the shortness diminished to three-quarters of an inch and since then has decreased to half an inch. The earlier paper was in the nature of a preliminary report. We now propose to present the result of this form of treatment in a considerable number of cases.

The conception that lumbar sympathectomy might cause enhancement of the rate of growth of the lower extremity is based upon the observation that certain pathological conditions in growing children can result in overgrowth of the involved extremity. The diseases in which this phenomenon occurs are all accompanied by prolonged hyperaemia in the neighborhood of epiphyseal lines, usually the result of inflammation, but sometimes the result of passive congestion. This observation is amply supported by cases presented in the previous paper, and since then further cases illustrating this condition have been collected. Such varied diseases as synovial tuberculosis of the knee joint, hemophylic knee joints, Brodie's abscess of the lower end of the femur or the upper end of the tibia, arteriovenous aneurysms, hemangioma of the lower extremity, certain tumors of bone, prolonged low-grade inflammation of the soft tissues in the vicinity of the knee joint, and femoral thrombophlebitis have all resulted in overgrowth of the involved extremity. From our observations, it seems definite that prolonged increase in the blood supply of growing epiphyseal lines can cause them to grow more rapidly than would otherwise be the case. It is reasonable to expect that the increase in blood supply which follows lumbar sympathectomy would produce a similar effect. Our clinical experiences during the last five years lead us to believe that, under appropriate circumstances, appreciable enhancement of the rate of growth of the leg can be obtained by lumbar sympathectomy.

* Read before the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

LITERATURE

Since the publication of our previous paper, several writers have reported upon experiments designed to show the effect of lumbar sympathectomy upon the rate of growth of the lower extremity. Bacq observed no increase in the growth of the lower extremities of kittens and infant rats after complete unilateral sympathectomy. From observations based upon three kids and one half-grown monkey with partial paralysis of the lower extremities from poliomyelitis, Bisgard was unable to find any evidence of acceleration of growth in periods of observation of eight months and six months, respectively. On the other hand, Horton, reporting twenty-three cases of congenital arteriovenous fistulae, notes that overgrowth of the involved extremity is a nearly constant feature.

Pearse and Morton, in an excellent paper on the stimulation of bone growth by venous stasis, demonstrate by a series of experiments that fractures unite more rapidly in the presence of venous stasis than would otherwise be the case. Also they cull from the literature many interesting examples of overgrowth of the extremities, the result of venous stasis. These observations parallel our own in those examples of overgrowth of the lower extremity which have followed extensive thrombophlebitis of the femoral and iliac veins.

EXPERIMENTAL DATA

The result obtained in our first patient and the observations which we had made upon the circumstances under which overgrowth of an extremity can occur made some attempt at experimental investigation of the problem desirable. During the five years which have elapsed, we have undertaken three series of experiments upon kittens, puppies, and lambs. Ten kittens were operated upon under anaesthesia, and, by a transperitoneal approach, the left lumbar sympathetic chain was removed. In the kitten, the lumbar sympathetic chain is an exceedingly small and frail structure. Evidences of enhanced circulation to the leg in the form of increased warmth of the foot occurred in about half of the cases, but this effect was transient. In none of the kittens was the increased warmth as marked as it is in human beings, and in none was it sustained. Difficulty was encountered in rearing the kittens under laboratory conditions. Dietary disturbances and rickets resulted in the death of several. In the animals which reached maturity, definite evidence of overgrowth of the left lower extremity was lacking. In two cases, the bones of the left leg, removed at maturity, were longer than the bones of the right leg, but in both of these animals there was such a degree of rickets that the difference in length of the extremities could not, with certainty, be attributed to the effect of sympathectomy.

Twelve puppies were operated upon in a manner similar to the kittens (removal of the left lumbar sympathetic chain through a transperitoneal approach). In none of these animals was there clear-cut evidence of increase in the circulation of the left lower extremity as evidenced by

increased warmth of the left foot. They were sacrificed when they reached maturity and in none could definite evidence of overgrowth of the extremity be found.

Eight lambs were similarly operated upon. By a transperitoneal approach, the left lumber sympathetic chain was removed. On account of our previous observations that prolonged venous stasis could of itself cause overgrowth of the limb, in three of these animals the external iliac vein was ligated and divided, in addition to the sympathectomy. In one, an attempt was made to create an abnormal arteriovenous communication by anastomosing the femoral artery to the femoral vein. Those animals which reached maturity were sacrificed. Examination and measurement of the bones of both lower extremities have not yielded definite evidence of overgrowth of the left leg.

Our experimental results have not been satisfactory. Apart from the difficulty of maintaining young animals in good health under laboratory conditions, we have not succeeded in reproducing in them sustained increase in the circulation such as is seen in human beings following lumbar sympathectomy. To this we attribute our failure to obtain overgrowth of the extremities.

CLINICAL OBSERVATIONS

In attempting to assess the merits of this procedure by observations upon patients, certain difficulties are encountered. The first is to determine why a limb, paralyzed by anterior poliomyelitis, fails to grow as rapidly as its fellow. It is by no means clear just why this deformity occurs, nor does the problem lend itself to experimental investigation. The rate of growth of an extremity is the resultant of many factors, both local and general. In this problem we are concerned only with local factors. Most important of these is the inherent growth energy of the cells of the epiphyseal line. As long as these cells remain intact, growth will continue. Only by their destruction can we cause cessation of growth. However, the basic rate of growth may be modified by a variety of factors. We have already demonstrated that certain pathological conditions can increase the rate of growth,—arteriovenous aneurysm, prolonged inflammations, and prolonged venous congestion. In the normal limb also it seems certain that there are accessory factors which stimulate the cells of the epiphyseal line to grow at a rate which is somewhat greater than the basic rate due to the inherent growth energy. From prolonged observation, it is our belief that there are at least two such factors: first, the stimulation which comes from contraction of normal muscles; second, the stimulation due to a normal blood supply. In poliomyelitis both of these accessory factors are diminished or absent. The paralyzed muscles can no longer provide the stimulus which accompanies normal muscular activity. Either from lack of use of the limb or from some obscure disturbance of vascular control, the circulation is subnormal, as evidenced by the cold, blue extremity. Lacking these stimuli, the growth of the limb subsides to

a rate which is dependent upon the basic growth energy of the cells of the epiphyseal line, and hence this limb grows more slowly than the normal limb.

Assuming that the diminished rate of growth of an extremity paralyzed by poliomyelitis is the basic growth rate of the epiphyseal line, and that it lacks the enhancement due to muscle action and adequate blood supply, it is evident that any attempt to compensate this shortness by the increased blood supply which follows sympathectomy is dependent upon the restoration of only one of the normal stimuli. Even though the increase in blood supply is great and results in a vascular supply far in excess of normal, the resultant growth rate may still be less than normal if paralysis is extensive. Under such circumstances, the increased growth rate due to hyperaemia may not be sufficient to compensate completely for the diminution in growth which results from lack of the stimulus of active muscular contraction.

Following sympathectomy, three effects upon the growth of the paralyzed leg are possible:

1. The increase in the rate of growth may not be sufficient to result in a completely normal rate of growth. In this case, the limb grows more rapidly than before the operation, but the rate is still subnormal; hence, shortness continues, but less rapidly than formerly.

2. The increase in rate of growth may be sufficient to make the limb grow as rapidly as the normal limb. In this case, while the shortness which existed at the time of operation remains unchanged, no further increase of shortness occurs, as would otherwise be the case.

3. The increase in rate of growth may be sufficiently great to result in more rapid growth than the normal limb. In this case, the shortness will steadily diminish during the whole of the period of growth. It is even conceivable that the increase in rate of growth might be so great and might be continued over so long a period of time as to cause the short limb to become longer than the normal limb. This, however, has not yet occurred in our experience.

From the considerations already expressed, it is evident that the extent of the paralysis of the involved limb will greatly influence the result of sympathectomy upon the growth rate. If the paralysis is extensive, it is unlikely that the increase in circulation will so enhance growth as to cause diminution of the shortness which already exists. The loss of the stimulus to increased growth which comes from normal muscular activity is too great to be completely overcome by the stimulus of increased vascularity. On the other hand, if the paralysis is less extensive, actual diminution of the shortness may be expected, especially if the operation is performed early in the patient's life.

It is obvious that the age at which the sympathectomy is performed will exercise a profound influence upon the ultimate result. It is only during the period of growth that any influence can be brought to bear upon the rate of growth. Therefore, the earlier the child is operated upon, the greater will be the ultimate effect.

A further factor which we have found of importance is the necessity of performing an operation which will result in permanent increase in vascular supply to the limb. Our earliest operations were ramisections after the method of Royle. In a fair percentage of these, the immediate effect of sympathectomy was a marked increase in vascular flow, but, after the lapse of several months, this effect subsided to the condition which existed prior to operation. We have reoperated upon three of these patients, performing a ganglionectomy at the second operation. In each case, immediate increase in the vascular flow occurred and has remained unchanged to date. We are strongly of the opinion that for this particular problem ramisection is not the operation of choice. The operation should always be ganglionectomy.

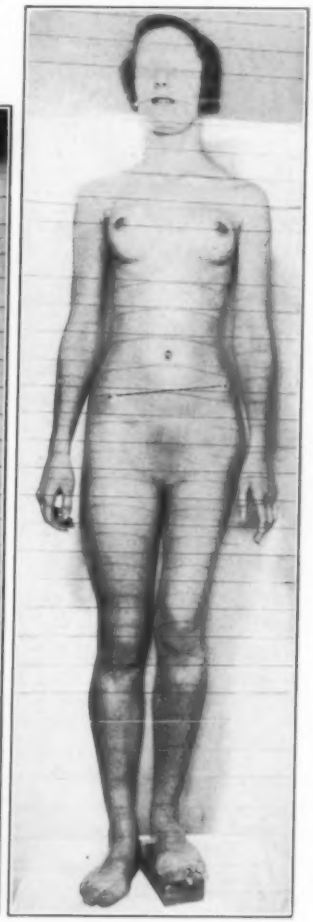

FIG. 1-A FIG. 1-B

Fig. 1-A: L. G., April 1928. Before ramisection. Shortness of left leg compensated by 1½-inch block.

Fig. 1-B: L. G., May 1934. Six years after successful ramisection. The block shown in Fig. 1 now raises the left side of the pelvis one inch.

NOTE: These and succeeding illustrations are reproduced from photographs taken with the patients standing behind screens of threads accurately spaced two inches apart. The black spots on the skin mark the positions of the anterior-superior spines. The interspinous lines have been drawn on the photographs to accentuate the levels of the anterior-superior spines.

CLINICAL CASES

In the five years which have elapsed since the publication of the report of our first case, seventy patients with short legs due to poliomyelitis have been operated upon by our associates or ourselves in an attempt to enhance the rate of growth by lumbar sympathectomy. We have recently reviewed forty-six of these cases, and our present summary is based upon this follow-up (66 per cent. of the total number of patients operated upon).

FIG. 2-A

E. R., April 1930. Before ramisection. Shortness of left leg compensated by 2½-inch block.

FIG. 2-B

E. R., October 1933. Three and one-half years after ramisection. Shortness of left leg now compensated by a 2-inch block.

FIG. 2-C

E. R., November 1934. One year after ganglionectomy. The same block shown in Fig. 2-B now elevates the left side of the pelvis one inch.

The first and most important outcome of our review is the demonstration of the fact that lumbar sympathectomy can appreciably enhance the rate of growth of a leg which is short as the result of infantile paralysis. It is our impression that a successful lumbar sympathectomy—*i.e.*, one which results in a sustained increase in circulation—always causes acceleration of the rate of growth. In not every case can this be proved, since even the enhanced rate of growth may still be subnormal in rate. Those cases, however, in which shortness is appreciably diminished present clear evidence of the beneficial effect of the operation. A situation which was causing progressive shortness is changed to one in which the involved extremity grows more rapidly than the normal leg and hence diminishes the shortness which already exists. In a less striking fashion, those cases in which the progress of the shortness ceases also demonstrate the value of the operation, since in them growth of the involved extremity has been increased sufficiently to keep pace with the normal limb.

A few case reports will serve to emphasize the fact that lumbar sympathectomy can greatly enhance the growth of an extremity.

L. G. was the first patient operated upon. Her condition was reported in our previous paper. She was ten years of age at the time of her operation. Her attack of infantile paralysis had occurred eight years previously at the age of two years. The left

leg was one and one-half inches short at the time of operation. There was extensive weakness of many muscles, although no complete paralysis. The operation was performed on April 25, 1928. She reached her mature height at the age of fifteen and has not grown materially since. In the two years which followed operation, the shortness diminished to three-fourths of an inch and, at fifteen years, the shortness was one-half an inch. The patient is now seventeen years of age and her leg is one-half an inch short. She walks without a limp and without a lift in her shoe, although she had a limp prior to her operation. (See Figures 1-A and 1-B.)

E. R., aged six years in 1930, had suffered infantile paralysis during her first year. On admission to the hospital, examination showed extensive paralysis of the left leg, varus deformity of the left foot, and two and one-half inches of shortness. The foot was stabilized by a Hoke arthrodesis and a left lumbar ramisection was performed. Three and a half years later, the shortness was two inches and the vascular effect of the ramisection had subsided. Lumbar ganglionectomy was, therefore, performed. This resulted immediately in the usual marked increase in circulation which has been maintained to date. One year after her second operation, the shortness was reduced to one and one-half inches. (See Figures 2-A, 2-B, and 2-C.)

D. F. aged twelve years in 1930, had passed through an attack of infantile paralysis at the age of three years. On admission to the hospital, examination showed extensive paralysis of the muscles of the left leg (especially those below the knee), drop foot, and one and one-half inches of shortness. Left lumbar sympathectomy was performed November 24, 1930. The increase in circulation has been maintained to date. Three years later, the shortness was reduced to one-half an inch. The foot has remained warm and dry. (See Figures 3-A and 3-B.)

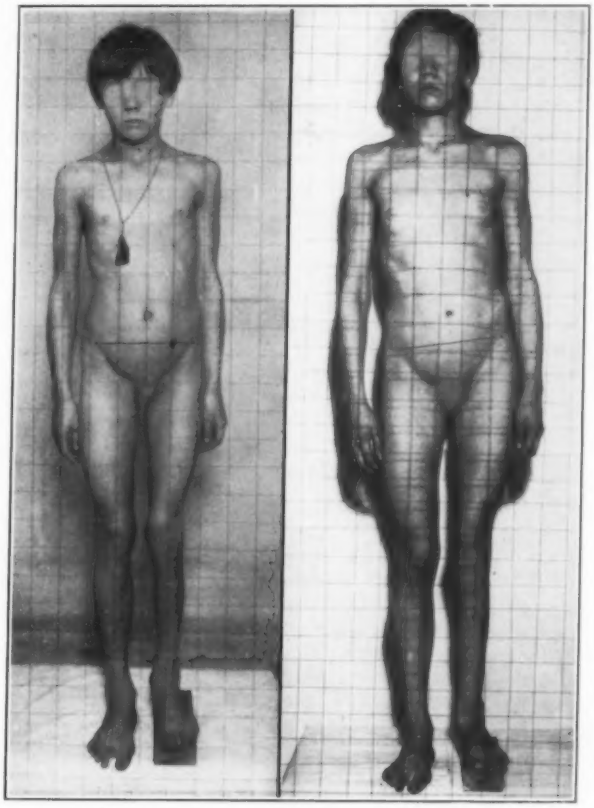

FIG. 3-A

D. F., November 1930. Before sympathectomy. Shortness of left leg compensated by 1½-inch block.

FIG. 3-B

D. F., November 1933. Three years after sympathectomy. The same block shown in Fig. 3-A now elevates the left side of the pelvis an inch.

Important and striking confirmation of the fact that lumbar sympathectomy will enhance the rate of growth of growing legs has been obtained by examination of those children who were treated for Hirschsprung's disease by left lumbar sympathectomy. In

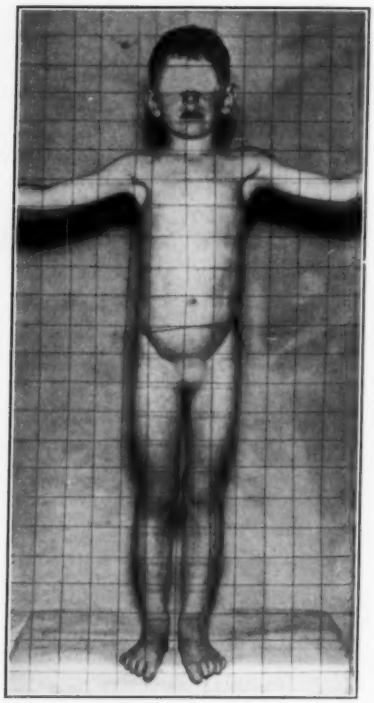

FIG. 4

R. T., six years old in 1935. The left leg is now three-quarters of an inch longer than the right as a result of left lumbar sympathectomy for Hirschsprung's disease four and one-half years ago.

our previous paper, we recorded and illustrated beginning overgrowth of the left leg (one-fourth of an inch) seven months after left lumbar sympathectomy had been performed for Hirschsprung's disease. This child has since died from causes not related to her primary disease and so is not available for reexamination at this time. However, among the seven patients who have been treated for Hirschsprung's disease at the Hospital for Sick Children in the last eight years, there are three upon whom the unilateral (left) lumbar ganglionectomy was performed. (The remainder were operated upon on both sides.) Examination of these three cases shows overgrowth of the left leg in each instance. The amount of overgrowth is as follows: R. T., a boy, now six years old, has three-fourths of an inch of overgrowth four years after left lumbar sympathectomy (Fig. 4); J. S., a girl, now four and one-half years old, has one-half an inch of overgrowth one year after left lumbar sympathectomy (Fig. 5); in the third case, that of a boy now eight years old, there is one inch of overgrowth five years after left lumbar sympathectomy. We have not been able to obtain a photograph of this patient.

OBSERVATIONS ON FORTY-SIX CASES REVIEWED

The forty-six patients whom we were able to reexamine constitute 66 per cent. of the number operated upon. Our failure to review a larger number is due to difficulties of transportation. Many of these patients live in outlying parts of the Province, several hundred miles from Toronto.

In twenty-one (46 per cent.) of the patients reexamined, the shortness had become less in amounts varying from one-eighth of an inch to one inch (Table I). In two cases the shortness was diminished by one-eighth of an inch; in six cases, by one-fourth of an inch; in seven cases, by one-half an inch; in four cases, by three-fourths of an inch; and in two cases, by one inch. The average age of this group at the time of operation was eight and one-half years. The time which had elapsed from operation to the period of review varied from seven years to one year. The amount by which the shortness is diminished is in propor-

tion to the time which has elapsed since operation. Sometimes, however, the rate of growth is very great and the shortness is diminished by three-fourths of an inch in one year. In one case, the shortness was diminished by one inch in one year. Much depends upon the rapidity with which the child is growing. Since children tend to grow rapidly at two periods, operation at these times may be followed quickly by striking change in the amount of shortness. It is particularly significant that in this group the effect of sympathectomy upon the vascular tree was permanently maintained in every case except one. In this patient the shortness has diminished by only one-eighth of an inch.

In eight cases (17 per cent.) in which lumbar sympathectomy was performed, the amount of shortness present at operation has remained unchanged. In other words, the progressive shortness has ceased. The rate of growth of the extremity has been enhanced sufficiently by the operation to equal the rate of growth of the normal limb. This may be fairly regarded as a definite beneficial effect from operation. The average age of this group was nine years. In one of these cases, the increased vascularity definitely was not maintained; and, in three others, the effect was slight.

These two groups represent the definitely beneficial results from operation and constitute 63 per cent. of the cases reviewed.

In seventeen cases (37 per cent.), the shortness progressed in spite of operation. The average age of this group was eight years. An extremely important observation in connection with these cases is the fact that in twelve (70.5 per cent.) the vascular increase which followed sympathectomy was not maintained.

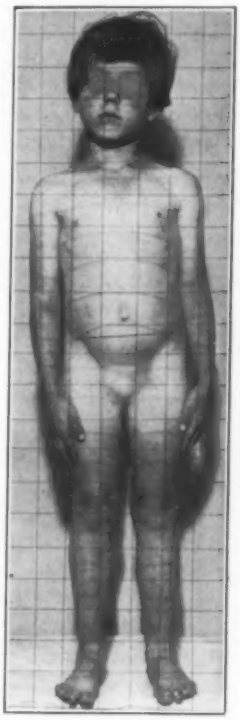

FIG. 5

J. S., aged four and one-half years in 1935. The left leg is one-half an inch longer than the right as a result of left lumbar sympathectomy for Hirschsprung's disease one year before the photograph was taken.

COMMENT

The most important observation which arises from a review of these cases is that, if the effect of sympathectomy upon blood flow is maintained permanently, the rate of growth of the extremity will be enhanced in a high percentage of cases. Thus, if we eliminate all the cases in which the sympathetic effect was not maintained, we have left twenty-nine cases. In twenty of these cases, the shortness diminished; in four, the progressive shortness ceased; and, in five only, the shortness increased. Therefore, in this group in which the sympathetic effect was maintained a beneficial effect upon rate of growth occurred in 82

TABLE I

EFFECT OF LUMBAR SYMPATHECTOMY UPON THE SHORTNESS OF THE LEG IN FORTY-SIX CASES OF ANTERIOR POLIOMYELITIS

Result	No. of Cases	Average Age	Vascular Effect Maintained	Lost
Shortness diminished following operation	21	8.5 years	20	1
Shortness remained as at time of operation	8	9.0 years	7 (slight in 3)	1
Shortness continued to increase following operation	17	8.0 years	5	12

per cent., or in twenty-four out of twenty-nine cases. (See Table II.)

Success in securing a permanent effect upon the vascular system is obviously of great importance. To be of most value, the increased blood flow must continue during the whole growing period of the child — a matter of several years. Our early ramisections in many instances failed to maintain the central vascular response. Ganglionectomy is better in this respect, but even following this operation we have had several cases in which the vascular increase has not been permanently maintained. The cause of this occasional failure is not clear, for the operations were all similarly performed. The ganglionated lumbar chain was removed from the point where it emerges from the crura of the diaphragm to the point where it disappears in the pelvis. The material removed was submitted to histological examination. It is known that one failure was due to inability to find the trunk.

Examination of these patients reveals that the cases most favorable for obtaining a definite diminution of shortness are those in which the paralysis is moderate in degree. In cases of extensive paralysis, especially those in which all of the muscles of one leg are paralyzed, it is not likely that actual diminution of such shortness as exists at the time of operation will be obtained. At most, the progressive shortness will halt. Even this result is important.

TABLE II

BENEFICIAL EFFECT UPON SHORTNESS WHEN SYMPATHETIC EFFECT IS PERMANENTLY MAINTAINED

Result	No. of Cases	Per Cent.
Shortness diminished following operation	20	82.00
Shortness remained as at time of operation	4	
Shortness continued to increase following operation	5	18.00

CONCLUSIONS

1. Prolonged increase in the blood supply to the lower extremity of a growing child can result in acceleration of the growth of the involved extremity.

2. The increase in blood supply which follows lumbar sympathectomy is capable, also, of inducing acceleration of the rate of growth.

3. The shortness which follows paralysis of the lower extremity from poliomyelitis is due to the loss of accessory factors which normally enhance the basic growth rate of the epiphyseal line. The known factors are the contractions of normal muscles and the maintenance of a normal blood supply.

4. Under appropriate circumstances, lumbar sympathectomy will diminish the shortness due to poliomyelitis.

5. The factors favorable to a good result are:

   a. Paralysis limited to one lower extremity.
   b. Paralysis moderate in degree.
   c. Early operation,—at the age of six years, if possible.
   d. Use of ganglionectomy rather than ramisection.
   e. Maintenance of the increased vascularity which follows the operation.

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OSTEOSYNTHESIS IN SPINAL TUBERCULOSIS *

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AND MARCEL GALLAND, M.D., BERCK-PLAGE, FRANCE

TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

The evolution of Pott's disease lasts a little more than three years. Throughout this period, the patient must remain recumbent, rigorously immobilized upon the plaster bed which is described later. The treatment is strictly conservative. No operative attack upon the focus of disease is ever practised. Throughout the whole course of recumbent treatment, the greatest care is taken to induce orthopaedic correction of deformity. In this respect, lumbar disease contrasts strikingly with dorsal disease.

Lumbar Pott's disease is easy to correct. The lumbar vertebrae are normally somewhat pressed together posteriorly, owing to the lumbar concavity, and, therefore, have a tendency to spontaneous intrafocal correction. Furthermore, lumbar lordosis close to the focus of disease is easy to achieve, thanks to the normal hyperextensibility of the lumbar spine. Hyperlordosis is attained, upon the orthopaedic table, by placing the patient prone and then simply lowering a central support. While the patient is in this position, the plaster bed is made. (See Figure 1.) Throughout the whole course of treatment, the patient lies upon this bed, which is renewed every three months.

This method is not applicable, however, in cases of dorsal disease. If the bed were made in this way, one would obtain only a lumbar lordosis, and would fail to attain hyperextension immediately above and below the focus of disease. Such lumbar lordosis would be objectionable in that it would render the dorsal gibbus more apparent. Accordingly, the patient is placed in the ventral position upon the orthopaedic table, but the central support is raised in order to prevent the development of any lumbar lordosis. A wedge of cotton-wool is now placed upon the back, at the level of the vertebra just above the diseased area; the higher the disease, the thicker the wedge. The object of this is to produce lordosis immediately above the focus of disease. Plaster is next modeled on top of the cotton-wool and to the back below this level. The cotton-wool is taken away, of course, before the patient is placed upon the plaster bed.

What are the indications for vertebral osteosynthesis in these conditions? This procedure should be carried out only at the end of treatment. If the operation is performed earlier, it interferes with the process of consolidation of the posterior segments of the vertebrae, which is a factor in intrafocal correction of deformity. Moreover, experience

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has proved that premature osteosynthesis does not shorten the duration of the disease, nor enable the patient to become ambulatory any earlier. It delays the evolution of the disease, but does not arrest it. It does not prevent increase of gibbus, formation and persistence of abscess, or paraplegia. In view of these facts, it is obvious that osteosynthesis should be practised only at a late stage, when the evolution of the disease has come to an end, and some months before the moment at which, according to classical conservative procedure, the patient would be allowed to begin to walk again. Osteosynthesis by means of a bone graft plays the part, then, of a protector, an internal orthopaedic corset, and a safety bolt, and it may aid in the cure by acting as a recalcifying agent.

The operation is carried out under local anaesthesia, by infiltration of all the tissues in the dorsal region. When the graft is taken from the tibia, the whole operative area is encircled and the nerve supply is blocked as it enters the nutrient foramen.

Our technique consists in the application of two short grafts, limited to the focus of disease and not extending to the vertebrae above and below this focus. Two rigid grafts, placed lateral to the spinous processes, are employed in the case of lumbar disease, and two supple or semisupple grafts in the case of dorsal disease. These grafts are applied after section of the spinous processes and roughening of the laminae.

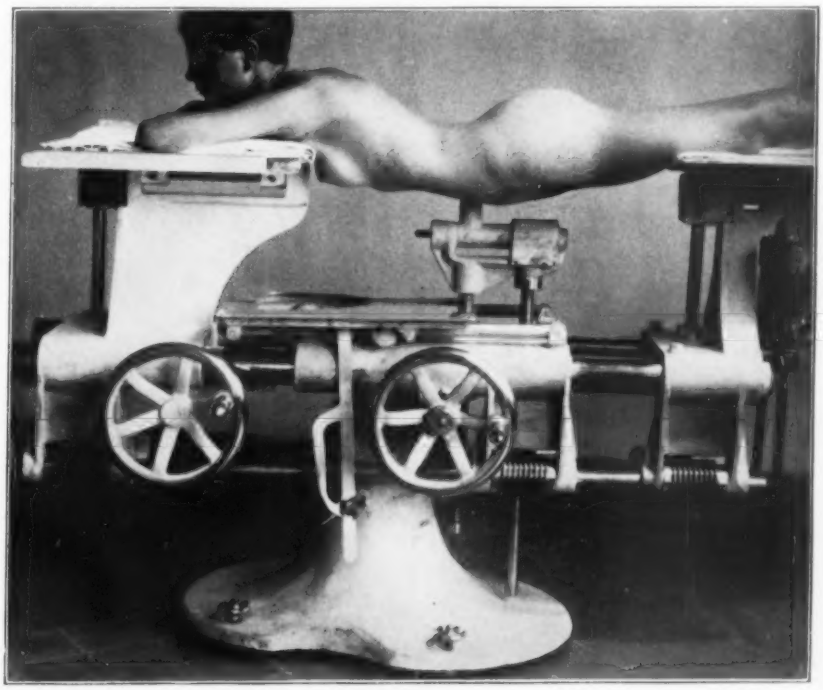

FIG. 1

Galland's orthopaedic table, showing patient in position for the application of the lumbar plaster bed.

Why do we use short grafts, limited to the immediate area of disease? Because experimental study of the mechanics of the condition and the observation of anatomical specimens have shown that the graft never fractures, undergoes absorption, becomes decalcified, or lengthens, except at the level of the focus of disease. Accidents of this kind are never observed above or below this area. It is evident, therefore, that bony material must be deposited in maximum amount at this level only. Furthermore, the long graft is objectionable, in that it hinders the development of compensatory curves above and below the diseased vertebra and prevents compensatory changes in the healthy intervertebral discs. There is also the danger that it may act as a rigid lever and thus serve to multiply a flexional strain which is at all times disadvantageous.

Special tools which are used in our operations include the electrically-driven saw of de Martel, Galland's apparatus for fixing the leg during the separation of the graft, Ombrédanne's chisel (used in freshening the spinous processes), Hue's chisel, and curved gouges for roughening the laminae in the dorsal part of the spine.

NOTE: The discussion of other phases of the subject also included in the presentation at the Meeting will appear in a subsequent issue of *The Journal*.

ARTHRODESIS OF THE HIP FOR COXALGIA IN CHILDREN *

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TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

A certain number of children can be cured by orthopaedic and climatic treatment, if this treatment is instituted early.

The number of "cures" has been reduced by the differentiation of Legg-Calvé disease and a number of other non-tuberculous conditions, and the number is still further reduced, if the various bacteriological tests for tuberculosis that are now available are rigorously applied.

By the term "cure" one should mean that the disease is arrested, suppuration has been prevented, the articular surfaces are unaltered in shape, and the mechanics of the affected joint are unimpaired. Furthermore, the joint should function painlessly, and there should be no relapse.

In the case of a child in whom the process of natural cure has not resulted in ankylosis in good position or useful function at the joint, the coxalgia should be cured, and the solidity and painlessness of the joint should be insured by the performance of arthrodesis.

When there is considerable destruction of bone, it is unnecessary to wait for any great length of time in the hope that good function will ultimately be regained; nor is it essential to wait until the local pathological process has come completely to an end. Operative treatment need be delayed only until the general health of the patient has been improved by immobilization under favorable climatic conditions (especially by residence at the seaside) and until the stage of bacillaemia is thought to be past. It is important, also, to satisfy oneself that there is no abscess present which would be encountered in the course of operative interference.

Since the greater trochanter does not ossify until eleven years of age, a graft should not be implanted in the trochanter of a child, but in the upper part of the femoral shaft. However, both in children and in adults, the author prefers not to use a graft, because this material dies and is liable to be absorbed a long time before it has been reossified and has become solid. The technique used is that of the "*pont-levis*", described by the author in 1932[1], which has been adopted by our Italian colleagues, Raffaele Zanoli and Ugo Camera, under the name of "*ponte-lavatoio*". This operation does not involve the use of a bone graft in the ordinary sense, but, rather, a thin layer of the outer table of the iliac bone and its periosteum. This layer is left firmly attached to its bony base or origin,

* Presented at the Spring Meeting of the British Orthopaedic Association, Berck, France, April 26, 1935.

but is bent in a hingelike manner, and its tip is then embedded in a split made in the trochanter. If the hip is in a faulty position which cannot be corrected by manipulation under anaesthesia, a subtrochanteric osteotomy is also performed. The hip is immobilized in a plaster cast which reaches to the knee. The author uses the orthopaedic operating table, designed by Lance, which permits the application of the plaster immediately after the operation, without changing the patient's position.

Four months after the operation, the patient is allowed to walk. After a further period of six months, during which the bony bridge undergoes considerable hypertrophy, the patient is allowed to walk freely, without apparatus of any kind.

The immediate results are good. The gait is confident and easy, and the patient is free from pain. The residual limp can never be wholly disguised, but the patient learns to mask it by compensatory movements of the pelvis and of the knee. The earliest cases in which this procedure was used date from 1926, and the late results show that relapse does not occur after an arthrodesis which effectually immobilizes the hip.

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TREATMENT OF QUIESCENT TUMOR ALBUS AND PSEUDARTHROSIS OF TUBERCULOUS ORIGIN IN CHILDREN *

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TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

For the past seven years, at the Maritime Hospital in Berck, on the Service of Dr. Richard, efforts have been directed toward the improvement of the technique and end results in cases of tumor albus of the knee.

A fairly large proportion of these cases are of five to six years' duration. When untreated, or treated on conventional lines, these patients are left at the age at which resection is appropriate with very real disability, which has a tendency to increase in severity.

In certain knees, the disease appears to be arrested, but the patient is left with a movable, unstable, painful pseudarthrosis which is a frequent source of pain and of relapse. Slight deformities become greater, and give rise to serious consequences, in spite of the conscientious application of all the ordinary accepted principles of treatment. Prolonged splintage does not suffice to prevent this unfortunate result.

Correction of deformity by manipulation alone, or by osteotomy, is merely palliative and does not overcome the mobility at the joint, which is the fundamental cause of the repeated and late relapses. Long ago, Broca showed that intra-epiphyseal resections were unreliable, as far as their end results were concerned, and we, too, have found that even the most careful operations, performed upon epiphyses that are still soft and growing, are liable to be followed eventually by serious deformity.

In the hope of overcoming this difficulty, various workers have adopted entirely different principles of treatment. Vignard and his associates have tried enucleation and filling of the epiphysis, while Robertson-Lavalle and others have used transepiphyseal grafts. The results of these procedures have been so uncertain, that we have made no regular use of the methods.

The striking success of arthrodesis of the hip in cases of coxalgia has encouraged surgeons to try to apply a similar procedure to cases of quiescent tumor albus of the knee. The method is also applicable to cases of old and severe pseudarthrosis, especially when, because of the patient's age, a standard resection of the knee is impossible.

There are available several different methods of inducing fusion in the slowly developing forms of disease in the knee, such as the unstable, painful, movable knee joint.

Intra-articular arthrodesis by transepiphyseal bone-pegging (the classical method of Lexer, Tuffier, and Lance) has been simplified by Richard

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and has often been employed by him in older children. After removal of the articular cartilages, a rigid graft, taken from the tibia of the healthy limb, is driven obliquely through the epiphyses. The results obtained by this very simple method are good. However, the method should be restricted to cases in which there has been no gross destruction of the epiphyses and in which recalcification has very largely taken place; it should, moreover, be confined to the dry forms of the disease. In spite of these precautions, the graft sometimes becomes absorbed and breaks in the space between the femur and the tibia.

Juxta-epiphyseal arthrodesis by means of peripheral grafts, after the manner of Dupuy de Frenelle, also gives good results. Several series of favorable statistics have been published, especially by Italian surgeons.

Both of these methods are open to the objection that it is necessary to open the joint through tissues in which the disease is by no means extinct.

In 1933, we perfected a completely extra-articular method of arthrodesis,—namely, anterior femoro-patello-tibial arthrodesis. A long, supple, curved graft, of ample thickness, is cut from the tibia of the healthy limb and is fixed at each end into two notches in the femur and tibia respectively, while, at the center, it is slipped beneath two flaps cut from the anterior surface of the patella.

Since the introduction of this method, we have employed it in more than thirty cases. At the present time, we use it only in the more chronic forms of the disease, and in children who are over ten years of age. We have found that in younger children the deformity is liable to recur later on, in spite of the correct application of the graft at operation.

Although sufficient time has not elapsed to warrant the drawing of conclusions, we do not believe that the ultimate growth of the limb is liable to be arrested. In order to avoid any possible trouble from this source, we prefer at present to perform the operation only on children in whom epiphyseal growth and ossification are relatively advanced.

The technique is delicate, because of the difficulty of taking the graft correctly. At first, there resulted several cases of pseudarthrosis and of fracture of the graft, although these mishaps were easily remedied. There are certain devices whereby errors in technique may be overcome. For instance, if a graft proves to be too short, it may be divided transversely in the middle: one piece is then affixed to the upper margin of the patella; the other, to the lower. Zanoli employs a very similar method, with success. He uses a long, pedicled, tibial graft which he bends backward and attaches to the femur. The two methods can be employed in combination.

With or without modification, the operation is of value if used in well selected cases, and insures good consolidation. Abundant proof of the solidity of the knee has been forthcoming on many occasions. The most typical case is that of a girl of fourteen with a severely paralyzed knee, a much shortened limb, and such severe trophic changes that intra-

epiphyseal resection was quite out of the question. An arthrodesis of the type described was performed and, when examined two years later, the patient showed an excellent result.

At the age that we are considering, a certain number of cases of severe tumor albus show arrest of active disease, with imperfect fusion of the bones and deformity. When the deformity is severe, the classical methods of correction are notoriously inadequate. For the last seven years, we have been employing a very useful method of obtaining the necessary correction,—namely, posterior capsulotomy by an anterior approach. By this means, it is possible to divide the contracted posterior portion of the joint capsule at the level of the articular condyles and to obtain complete extension of the joint, without interference with the bones themselves. We consider this to be the method of choice in the treatment of severe flexional deformity of the knee, whether simple or complicated. As a preliminary measure, it is wise to carry out tenotomy of the hamstrings and the tendo achillis. When full extension has been restored, its maintenance can be insured by the performance of an arthrodesis.

These various operative measures now provide adequate treatment for forms of the disease which hitherto have been treated only with imperfect success.

SURGICAL TREATMENT OF SACROCOXALGIA*

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From the Maritime Hospital, Berck-Plage

Sacrocoxalgia is rare in the child, who is more likely to develop juxta-articular osteitis, often of the benign type. The treatment is preventive, with the object of avoiding articular involvement. On the other hand, sacrocoxalgia is frequent in the adult. Fifty-four cases have been seen in the Maritime Hospital at Berck since 1930. If a tuberculous lesion is present, the prognosis is grave, but it may be considerably ameliorated by well directed treatment.

To be efficient, treatment should be begun in the early periods of the development of the affection. The principle of this therapy consists essentially of thorough and prolonged immobilization of the patient, under the most favorable hygienic conditions, in order to aid him in combating the tuberculous infection. These conditions are found in the marine heliotherapy which is indispensable to these patients. Immobilization is obtained by the usual orthopaedic methods and, still better, by well directed surgery.

Sacro-iliac arthrodesis, in addition to the biological influence of the graft, is also an aid to immobilization. Two procedures are commonly employed,—the arthrodesis by the peg or graft and the double extra-articular arthrodesis, as practised by Dr. A. Richard, Surgeon-in-Chief at the Maritime Hospital at Berck.

In the arthrodesis by the graft or peg, a solid graft, two centimeters in thickness and from six to seven centimeters in length, is taken with the chisel from the internal surface of the tibia and is narrowed at one of its extremities. A curved incision along the crest of the ilium allows the exposure of the posterior part of the external iliac fossa. The point of entrance of the graft is then marked. This point is determined according to the indications of Piéri,—at four centimeters from the top of the posterosuperior iliac spine and at three centimeters from the external surface of the iliac crest. The drill is entered perpendicular to the surface of the ilium to direct the course of the graft, which passes through the iliac bone and the wing of the sacrum.

For the double extra-articular arthrodesis, a solid graft, one centimeter thick and twelve to fifteen centimeters long, is taken and is cut into two pegs of equal length. A long curved incision, with the concavity inferior, exposes the posterosuperior iliac spine and the crest of the sacrum. After the marking and drilling, the bone grafts are placed in position from the spine of the ilium to the first two spinous processes of the sacrum.

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To obtain from the arthrodesis the results which one should reasonably expect, it is necessary to understand thoroughly the indications and to employ this method at the proper time, under well controlled conditions, and according to a definite technique.

It is very important that the field of operation be free from all infection, and it is for this reason that arthrodesis by graft is not applicable except to localized forms of sacrocoxalgia,—that is, those situated in the lower portion of the sacro-iliac joint. The double extra-articular arthrodesis of Richard is applicable to all cases, for it gives increased security from the technical point of view.

The operative procedure, however, is not the chief consideration; much more important are the indications for its use. The arthrodesis should be performed early, but conservatively,—that is, the patient should always be prepared for this operation by several months' rest under the best climatic conditions. Marine heliotherapy exerts a most favorable influence upon the defensive reactions of the organism against bacteriological infection which contra-indicates the operation.

Arthrodesis should be performed only when the surgeon is sure that the operative area is free from infection and that no abscess exists. One should never run the risk of opening a focus during the operation.

The postoperative care is necessarily prolonged. The general treatment and rest should be rigorously continued for six months after the operation. Arthrodesis is not a curative treatment; it is simply an adjuvant of first importance and should not be considered as the only therapeutic measure.

In sacrocoxalgia with infection, it is absolutely necessary to obtain a thorough drainage of the lesion. The infected abcess should be given a thorough débridement. A deep, infected area drains imperfectly and should be treated by resection,—either by an atypical resection, according to the method of Ollier, or by a partial resection, according to the method of Picque.

After the posterior iliac spines have been exposed, the posterior surface of the sacrum is removed by the chisel, thus exposing the articular area which is then evacuated according to the indications. This process frequently extends in front of the articulation and thus drains the collection in the pre-articular space.

Infection constitutes the most grave complication of sacrocoxalgia, but well conducted treatment—arthrodesis performed at the opportune time and according to the principles which have been explained—should prevent infection.

CHRONIC OSTEOMYELITIS ASSOCIATED WITH MALIGNANCY

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Malignant change following chronic osteomyelitis with draining sinuses has been recognized for many years, but the condition has been so rare that many of the papers written have been reports of single cases. There seems to have been more interest in this subject in the years prior to 1910 than there is at present, probably because the treatment of chronic osteomyelitis with draining sinuses was not as adequate then as it is now. Benedict[1] reviewed the subject thoroughly in 1931. Of 2,400 cases of chronic osteomyelitis treated at the Massachusetts General Hospital, he found twelve in which the osteomyelitis was associated with carcinoma. In each case the carcinoma was in the lower extremity. The tibia was involved in eight cases, the foot in three, and the femur in one. Benedict, like earlier authors, recognized two types: the superficial tumor, easily diagnosed, and the deep tumor in which the carcinomatous cells line the walls of the cavities which are produced by the osteomyelitis.

Of 2,396 cases of chronic osteomyelitis seen at The Mayo Clinic up to July 1, 1934, only five, or 0.208 per cent., were associated with malignant changes. Of these patients, one was a woman and four were men. The ages varied from forty-five to sixty-one years, averaging fifty-two and two-tenths years. Draining sinuses of chronic osteomyelitis had been present from twenty-seven to forty-eight years; the average period was thirty-seven years. In four cases, the disease had followed acute osteomyelitis; and, in one case, it had followed a compound fracture. In all of these cases there was a history of sinuses which had closed and then opened again at a later date, sequestration of bone, and other symptoms characteristic of the behavior of chronic osteomyelitis.

The reasons given for seeking medical advice after so many years of chronic disability were much the same in each case,—swelling, increase in pain, hemorrhages, and more profuse discharge. The appearance of an abnormal growth within a few months before coming to the Clinic was the reason advanced in two cases.

On examination, the typical draining sinus surrounded by scarred skin was seen in each case. In one case, a growth the size of a tangerine (6.2 centimeters) was found. In another case, an ulcerating area, four inches (10.16 centimeters) in diameter, which was the site of a cauliflower-like growth, was seen. In a third case, there was revealed a discharging sinus, the size of a silver dollar (3.5 centimeters), which had raised edges

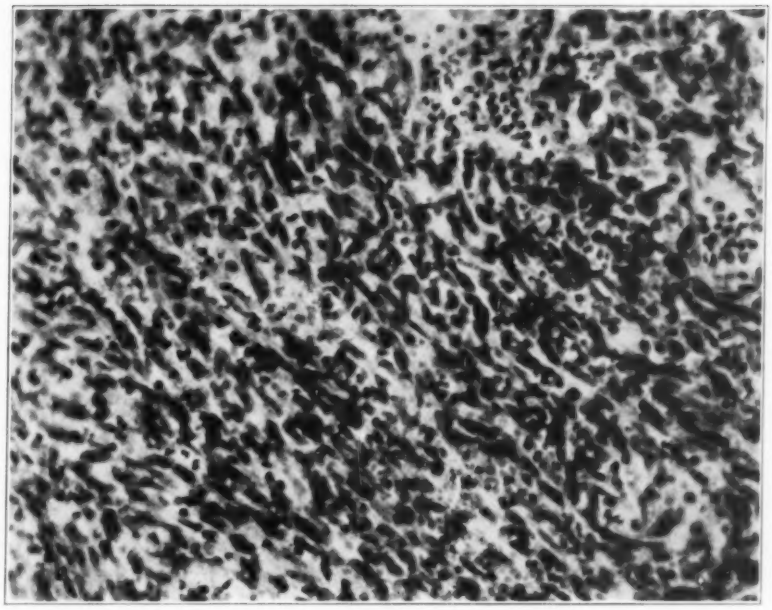

FIG. 1
Fibrosarcoma, grade 3 (× 215).

and resembled an epithelioma. The fourth patient presented a draining sinus in close proximity to a swollen, tender ankle. This was the patient who had had hemorrhages. The fifth patient presented a foul-smelling, fungating, papillomatous mass. A foul odor was mentioned in two cases. In four of the five cases, the regional lymph nodes were found to be enlarged and firm. Interference with joint motion, which was the result of the osteomyelitic process, was found in two cases. In four of the five cases, roentgenograms showed the typical irregular sclerotic changes always seen in chronic osteomyelitis.

Examination of the urine and blood did not reveal anything of importance. The Wassermann reaction of the blood was negative in four of the five cases.

In the first two cases, amputation was at once performed. In the other three cases, a biopsy was done first.

In four cases, the lesion was situated in the lower third of the leg. In three of these cases, amputation was performed at the junction of the middle and upper thirds of the leg; in the other case, a Gritti-Stokes operation was done. In the fifth case, in which the neoplastic process was near the hip joint, local excision was done, followed by cauterization and the use of deep roentgenotherapy and radium. As in Benedict's series, the lower extremity was involved in all of these cases.

The pathological findings revealed: epithelioma, grade 1, in two cases; epithelioma, grade 2, in two cases; and, in the other case, fibrosarcoma, grade 3, which was associated with squamous-cell epithelioma, grade 3.

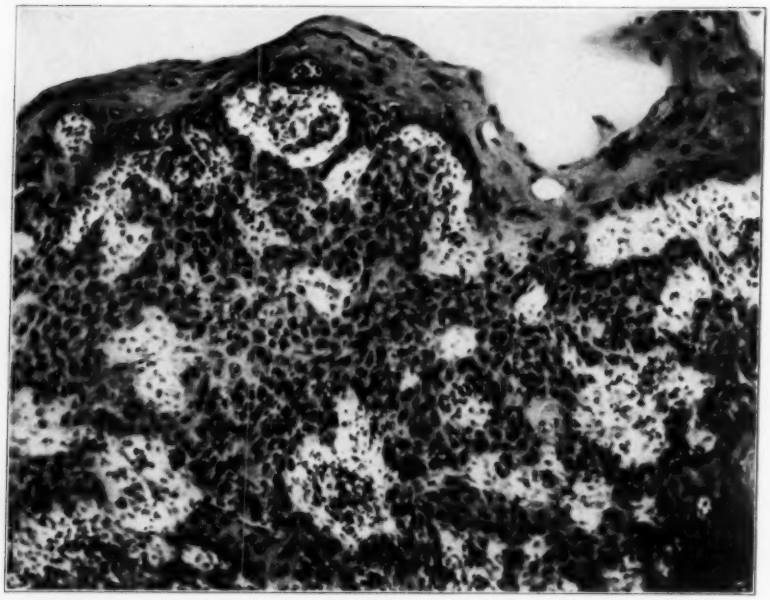

FIG. 2
Squamous-cell epithelioma, grade 3 (× 95).

This was the only case in our series in which sarcoma and carcinoma were associated, and we were able to find reference to only two other cases in the literature. The patient in our case was a man who had suffered a compound fracture of the lower ends of the tibia and fibula in 1911. Chronic osteomyelitis had developed, and, as the patient lived near the Clinic, he was seen at intervals thereafter. The sinus was curetted twice and skin grafts were applied once, but they did not live. In 1933, the patient had a great deal of pain and, after two hemorrhages had occurred, a biopsy was done. This revealed fibrosarcoma, grade 3. The leg was amputated a week later. The stump healed, but, four months later, a large mass appeared in the groin of the involved side, which on excision proved to be squamous-cell epithelioma, grade 3.

Two of these patients received roentgen-ray and radium treatment postoperatively, and one received roentgen-ray treatment.

An attempt was made to determine the results of treatment in these cases. Two patients, who underwent amputation in 1925 and in 1929, respectively, were well and had good functioning stumps in June 1934. There had not been any local recurrences or evidence of metastasis in either case. Each of these patients had an epithelioma, grade 1. The patient who underwent an amputation in 1924 died of chronic nephritis in March 1935. He had not had any further trouble with his stump or any extension of the disease to other parts of the body. He had an epithelioma, grade 2. In the case in which local excision of the tumor was performed in 1921, the patient died at a later date, but the cause of

death could not be determined. The neoplasm in this case was epithelioma, grade 2. The patient whose leg was amputated for mixed fibrosarcoma and epithelioma in 1933 is in good health at the time of this report.

COMMENT

The rarity of the condition is evident when it is seen that it was found only five times in 2,396 cases of chronic osteomyelitis. The long history of drainage of pus from sinuses antedating the appearance of the growth is similar to that reported by other authors. The disease has always been found to affect males more frequently than females, and this was true in our series. The lower third of the tibia was involved in four cases and the femur was involved in one case. While enlarged inguinal lymph nodes were palpated in the groin in three cases, the involvement was not proved to be metastatic. No other evidence of metastasis was found. In the case in which sarcoma and carcinoma were associated, the growth of the inguinal mass followed the amputation and was a distant recurrence.

The reason for the growth of carcinoma in these cavities and sinuses has always been in dispute. The theory which most commonly is accepted is that the continuous drainage of pus irritates the skin to such a degree that malignant changes result. Why this should happen in so few cases is not clear. It may be that the resistance of the skin of middle-aged or elderly people is lessened, so that irritation from pus, which would have no effect on the skin of younger people, is able to initiate neoplastic changes. This conforms with the frequent finding of carcinoma of the skin among people of this age group. It is interesting to note that in four of our five cases the lesions were near the ankle, and that in the twelve cases reported by Benedict the lesions involved the tibia in eight, the foot in three, and the femur in one. It is possible, therefore, that the less efficient circulation in the lower end of the leg, particularly in people past middle age, and in scarred regions may weaken the resistance to irritation and predispose these regions to malignant change.

In the case in which both sarcoma and carcinoma were found, the reasons for this association and its significance are not known. Once the tendency to malignancy is present, the change is easily accomplished. It may be that the factor which produced irritation of the skin also irritated the bone and each reacted to produce malignancy. In this case, no external manifestation of new growth was evident. This patient complained of pain in the ankle and bleeding from the craterlike lesion in the tibia. For many years, he had had a stiff ankle with a draining sinus nearby, but the function of the leg had been good and he had had no trouble in getting around to do his work.

It is evident then that every effort should be made to induce healing of draining sinuses. It seems likely that the advent in recent years of more effective technical operative measures, followed by treatment such as the Orr treatment and the use of maggots and their extracts, undoubtedly will result in a lessening of prolonged drainage and subsequent

malignancy. All sinuses having a foul odor and those in which hemorrhage occurs and pain comes on for no apparent reason should be thoroughly curetted and the scrapings examined for evidence of malignant change.

Once the presence of a neoplastic process has been established, amputation should be performed immediately, and followed by postoperative irradiation.

CONCLUSIONS

1. In cases of chronic osteomyelitis every effort should be made to cause draining sinuses to heal.

2. If malignancy is suspected from the appearance of a mass, foul odor, pain, or hemorrhage, biopsy should be performed at once. If malignancy is found, amputation should be done immediately.

3. It is advisable to follow the amputation by treatment with deep roentgen rays or radium.

1. Benedict, E. B.: Carcinoma in Osteomyelitis. Surg. Gynec. Obstet., LIII, 1, 1931.

THE EFFECT OF LARGE DOSES OF X-RAYS ON THE GROWTH OF YOUNG BONE*

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Since the discovery of the roentgen ray, many studies have been made dealing with the influence of this ray upon the growth of various tissues. It was soon found that exposure of growing bone to appreciable doses of the roentgen ray resulted in retarded growth and permanent stunting. In 1933, Brooks and Hillstrom[1] published the results of an extensive investigation of this problem.

In a previous study[2], we not only found that exposure to x-rays retards the growth of young dog bone, but also that this inhibition of growth is accompanied by a marked diminution in the phosphatase activity of the bone. It has not been determined whether this reduction of enzyme activity is an important factor in the retardation of growth. In another experiment [3], it was found that exposure of the entire bodies of young rabbits to 1,100 roentgens resulted in a diminution in phosphatase activity of the entire animal as well as a decrease in body weight.

The object of the present study was to determine: (1) whether bone growth could be completely stopped by x-rays without destruction of the tissues; (2) if complete inhibition occurred, whether any degree of renewed growth took place before maturity of the skeleton; (3) whether, by careful measurements, evidence of any influence on the growth of untreated homologous bones of the same animal could be detected.

The plan of the experiment was to treat one foreleg of each of a large group of uniform animals with a heavy dose of x-rays, and to follow up to adult life the growth of both forelegs of these and a similar group of control animals by measurements of roentgenograms, made at regular intervals under standardized conditions.

PROCEDURE

A group of fourteen pedigreed, New Zealand white rabbits, twenty-five days old, were carefully selected. This group consisted of four small litters. Part of each litter was put in the experimental group and part in the control. Each animal was given an individual mark and its identity was maintained throughout the experiment. There were eight animals in the experimental group and six in the control.

Each of the experimental animals was treated with 2,600 roentgens

* Presented in part before the American Academy of Orthopaedic Surgeons, New York, N. Y., January 15, 1935.

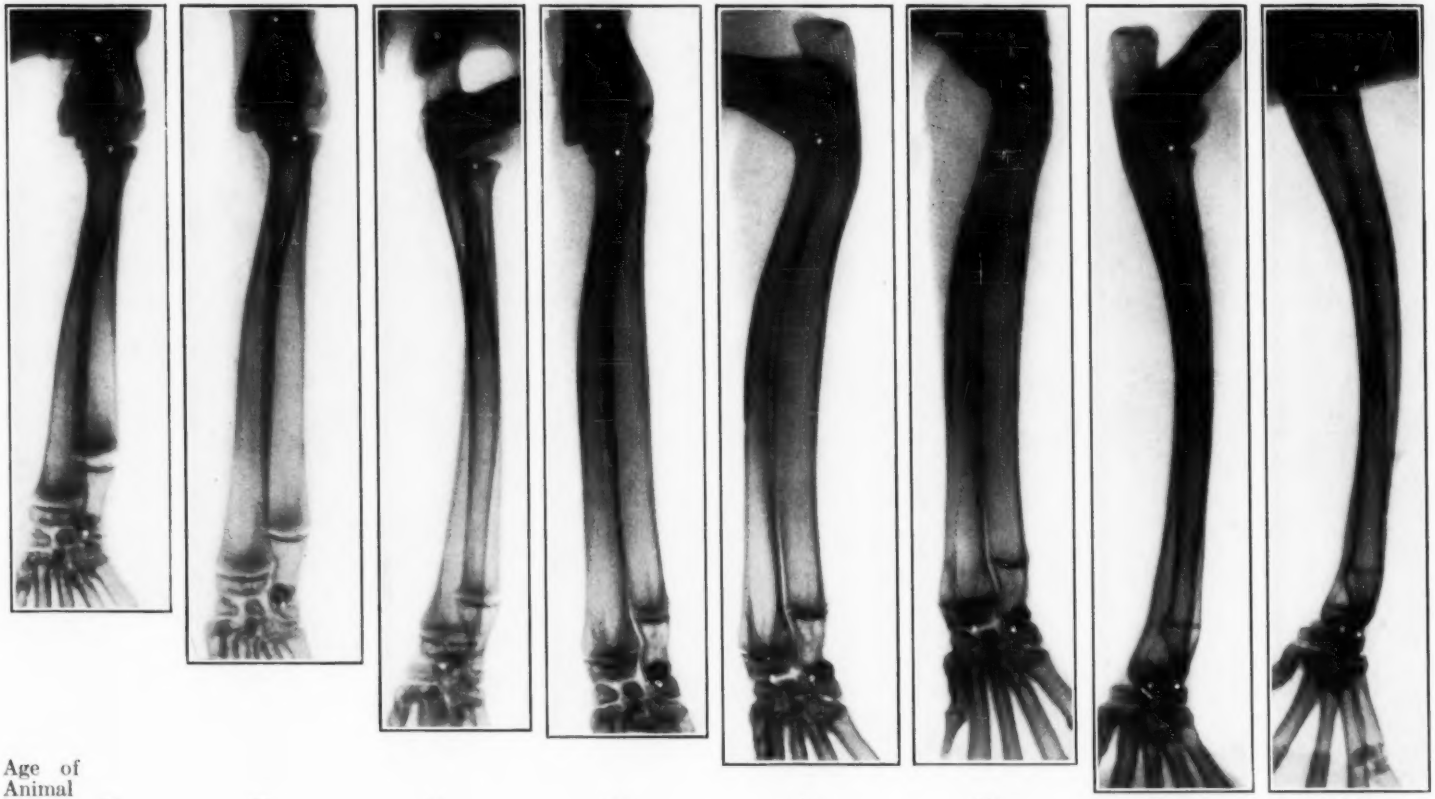

FIG. 1-A

Serial roentgenograms of right foreleg, untreated.

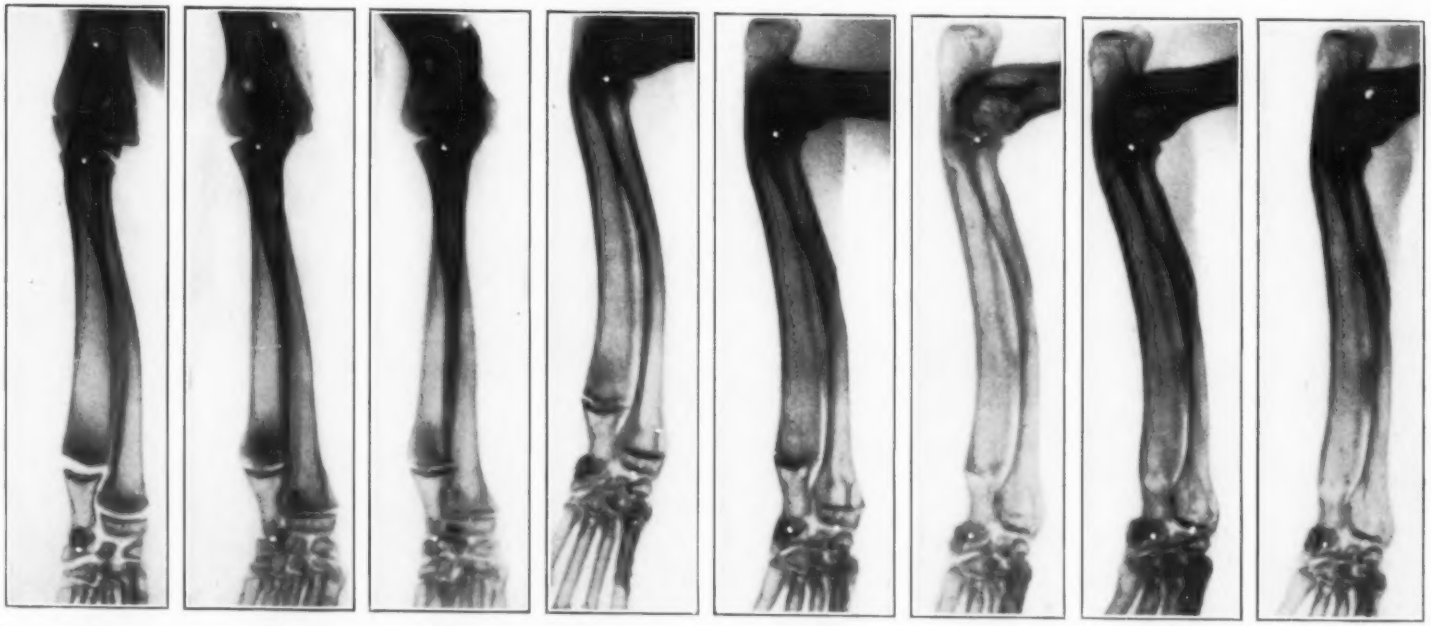

FIG. 1-B

Serial roentgenograms of left foreleg, treated with 2,600 roentgens at age of twenty-five days.

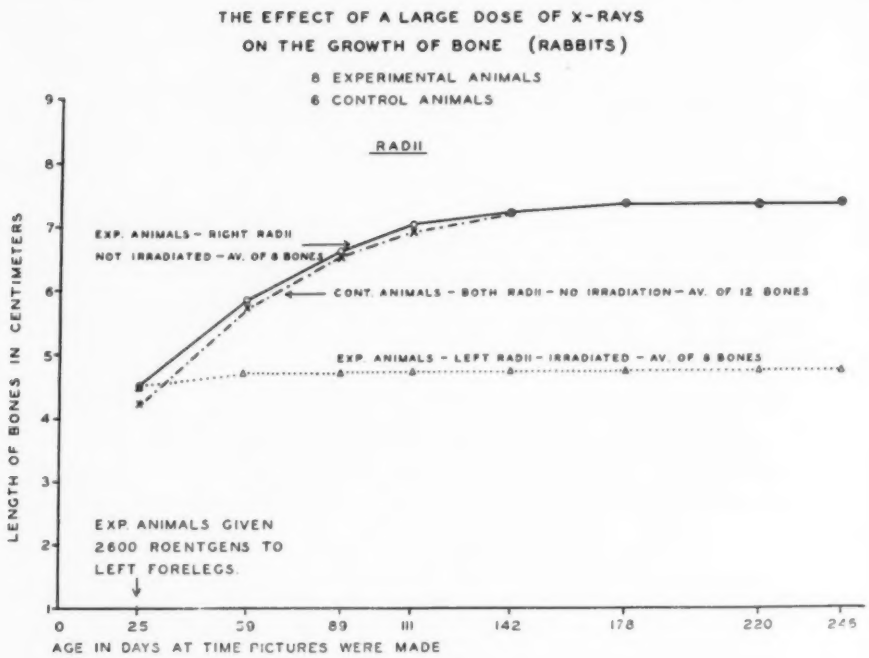
THE EFFECT OF A LARGE DOSE OF X-RAYS
ON THE GROWTH OF BONE (RABBITS)
8 EXPERIMENTAL ANIMALS
6 CONTROL ANIMALS
RADII
LENGTH OF BONES IN CENTIMETERS
EXP. ANIMALS - RIGHT RADII
NOT IRRADIATED - AV. OF 8 BONES
CONT. ANIMALS - BOTH RADII - NO IRRADIATION - AV. OF 12 BONES
EXP. ANIMALS - LEFT RADII - IRRADIATED - AV. OF 8 BONES
EXP. ANIMALS GIVEN
2600 ROENTGENS TO
LEFT FORELEGS.
AGE IN DAYS AT TIME PICTURES WERE MADE

FIG. 2

Curves plotted from measurements of the radii of: (1) untreated forelegs of experimental animals; (2) treated forelegs of experimental animals; (3) both forelegs of control animals. Each point on each curve represents the average value of all measurements of that group of bones made on day indicated.

over the left foreleg, including the lower half of the humerus and the entire foot. The remainder of the animal was completely protected with heavy sheet lead. As an additional precaution, a roentgen meter was placed at different positions within the shielded area and showed no measurable leakage of radiation to the protected part of the animal's body. All treatments were given on the same day. The dosage of 2,600 roentgens was given under the following conditions:

200 kilovolts
20 milliamperes
60-centimeter target-skin distance
1.0 millimeter of aluminum and 0.5 millimeter of copper filter
80 minutes' exposure.

Immediately following the treatment of the experimental animals, roentgenograms were taken of both forelegs of each of the animals, both experimental and control. These roentgenograms were followed by others at intervals of approximately one month, until three consecutive roentgenograms showed that growth had ceased in the control bones. Very careful technique was employed in making the pictures for the purpose of accurate measurements, special care being taken to make all the exposures under strictly uniform conditions. In each case, the animal was

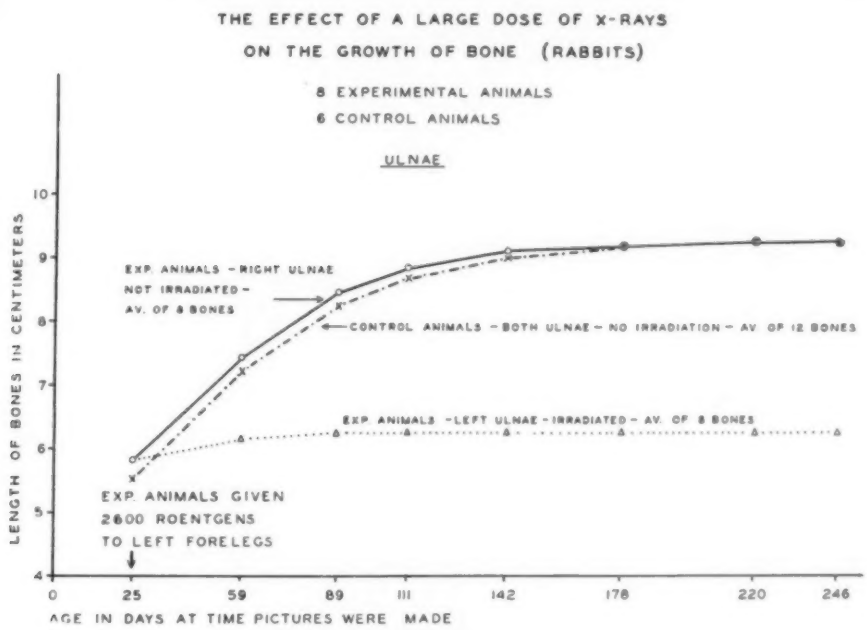
THE EFFECT OF A LARGE DOSE OF X-RAYS
ON THE GROWTH OF BONE (RABBITS)
8 EXPERIMENTAL ANIMALS
6 CONTROL ANIMALS
ULNAE
LENGTH OF BONES IN CENTIMETERS
EXP. ANIMALS - RIGHT ULNAE NOT IRRADIATED - AV. OF 8 BONES
CONTROL ANIMALS - BOTH ULNAE - NO IRRADIATION - AV. OF 12 BONES
EXP. ANIMALS - LEFT ULNAE - IRRADIATED - AV. OF 8 BONES
EXP. ANIMALS GIVEN 2600 ROENTGENS TO LEFT FORELEGS
AGE IN DAYS AT TIME PICTURES WERE MADE

FIG. 3

Curves plotted from measurements of the ulnae of: (1) untreated forelegs of experimental animals; (2) treated forelegs of experimental animals; (3) both forelegs of control animals. Each point on each curve represents the average value of all measurements of that group of bones made on day indicated.

held by two assistants and the roentgenogram included both forelegs. Both elbows and wrists were kept in firm contact with the cassette, and a constant target-film distance (forty inches) was used for all exposures.

In preparing for the measurements, each film was placed over a small viewing box and a pinhole was made in the film at the ends of each bone image. Points of dividers were placed in these holes and the measurements were made on a celluloid millimeter scale.

One hundred and four exposures were

FIG. 4

Front view of the forelegs of one animal, taken eight months after the left leg had been treated with 2,600 roentgens.

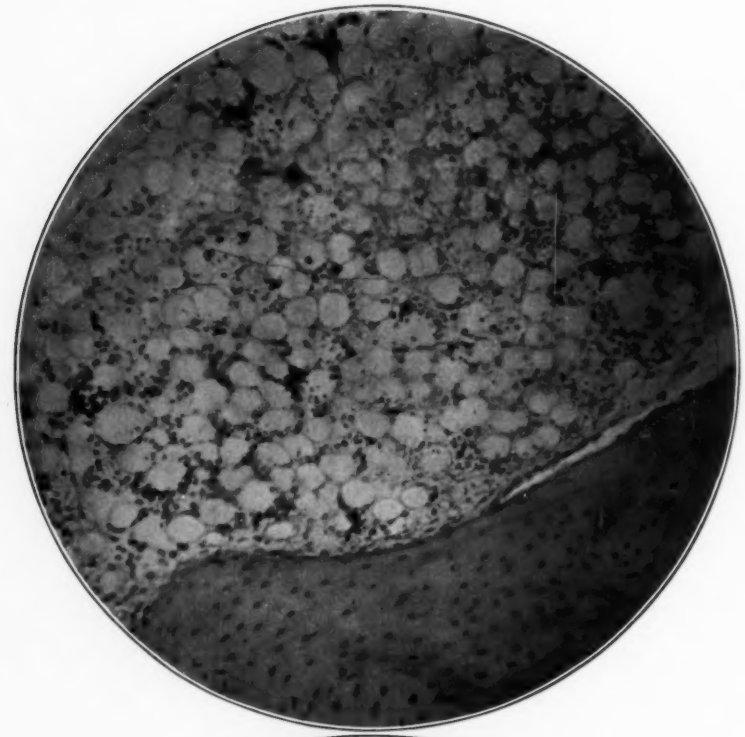

FIG. 5-B
Photomicrograph of left ulna, eight months after treatment with 2,600 roentgens.

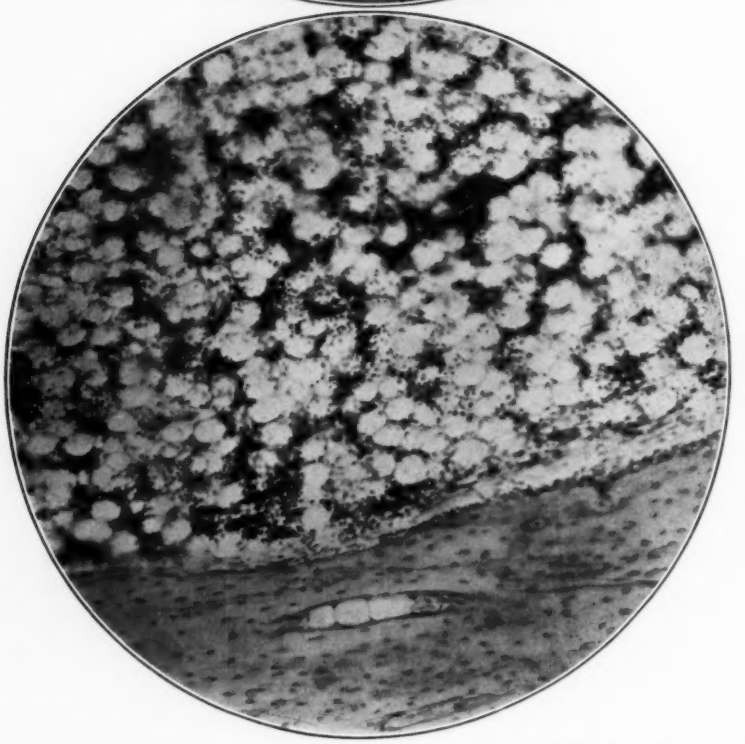

FIG. 5-A
Photomicrograph of right ulna, untreated.

FIG. 5-C

Photomicrograph of skeletal muscle from left foreleg, eight months after treatment with 2,600 roentgens.

obtained, representing 416 pictures of the individual bones. In forty-seven instances, it was impossible to determine definitely from the film the position of the end of the bones; thus, 369 actual measurements were recorded. A typical series of roentgenograms of the bones of both forelegs of one of the experimental animals is given in Figure 1. The position of the pinholes may be seen in some cases.

The results of the measurements of the radii are shown by curves in Figure 2, those of the ulnae in Figure 3. For purposes of comparison, the bones were divided into six groups, three groups each for the radii and the ulnae. The values for homologous bones of the control animals are plotted in a single curve. Those for the right and left forelegs of the experimental animals are of course plotted separately, since the left side was treated and the right untreated. At the time of irradiation, the bones of the experimental animals were slightly longer than those of the controls, since the larger animals of each litter were purposely chosen for treatment.

In every case, the treated forelegs showed evidence of x-ray burns to the skin with loss of hair and slight ulceration. The latter, however, healed promptly and the hair reappeared in a few months. A picture of one of the treated animals (Fig. 4), taken at the termination of the experi-

ment, is given to show the contrast between the two forelegs. Most of the hair was clipped from both legs to show more clearly the difference in size.

Sometime during the first thirty-four days following treatment, the irradiated bones increased very slightly in length. During the next interval between observations, the ulnae showed an extremely slight increase in length, which is almost within the error of the method of measurement. Following this, none of the treated bones showed any measurable growth. This held for the individual bones as well as for the averages. These findings show quite definitely that bone growth, as judged by length, can be completely stopped by exposure to a sufficient dose of x-rays, and that up to maturity of the skeleton no reappearance of growth occurs.

A difference in length persisted for several months between the bones of the control animals and the untreated bones of the experimental animals. During this time the control bones gradually gained on the untreated bones of the experimental animals until they finally became of equal length. Thus it appears that there is no generalized effect on the untreated bones in the experimental animals, as judged by the growth of the homologous bones of the opposite side.

After the last roentgenograms were made, several of the treated animals were sacrificed and the tissues of the forelegs were carefully examined. The gross appearance of the muscles and bones seemed to be normal. Microscopic sections were made of the normal and treated bones and the treated muscles. Photomicrographs of these are shown in Figure 5. These are included to show the condition of the tissues at the end of the experiment.

SUMMARY

Eight of a group of fourteen pure-bred young rabbits of the same age were treated over the left forelegs with 2,600 roentgens; the remaining six animals were used as controls. Roentgenograms of both forelegs of each animal were made at monthly intervals until growth in the controls had ceased. Growth in the radii and ulnae was followed by careful measurement of the roentgenograms for a period of eight months, giving a total of 369 observations. Sometime within the first month, growth in the treated bones stopped completely and did not reappear during the period of observation. Growth in the untreated bones of the experimental animals was not affected.

Part of the expense of this investigation, as well as of the experimental work described in the paper which follows, was borne by a grant from the Division of Medical Sciences of the Rockefeller Foundation.

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THE INFLUENCE OF ROENTGEN IRRADIATION ON THE RATE OF HEALING OF FRACTURES AND THE PHOSPHATASE ACTIVITY OF THE CALLUS OF ADULT BONE *

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Within a few years after the discovery of the roentgen ray, it was learned that exposure of growing bone to this ray results in a decrease in rate of growth. Not only is this true, but also the bone is permanently stunted, never attaining the length and weight that it would normally have reached. Within certain limits there is some degree of correspondence between the quantity of irradiation and the effect produced. In the preceding paper, it was found that exposure to 2,600 roentgens completely stops growth of young rabbit bone as judged by length. Brooks and Hillstrom[1] have recently made a study of the effect of x-ray irradiation on the bones of dogs and rabbits under various conditions. They suggest that the mechanisms of growth and repair of bone may be quite different and thus not show the same reaction to x-ray irradiation. Some authors have suggested a stimulating effect on healing of fractures as a result of mild x-ray therapy. Within recent years, various other factors have been studied for their effect upon the healing of fractures. With doses within the clinical range, Brooks and Hillstrom could detect no changes in the repair of experimental fractures in rabbits when they were treated with x-rays *after* the fractures had been produced. The x-ray treatment was given from one hour to sixteen days following production of the fractures.

In a previous study[7], we found that the phosphatase activity of growing dog bone was markedly reduced following moderate doses of x-rays, the decrease beginning a few days after treatment. This activity reached the minimum value within about a week, and showed a distinct tendency to go up again within four to five weeks. Had the animals been permitted to live to maturity and had roentgenograms been made at regular intervals, it seems possible that the period of the greatest retardation in growth might correspond to the period of minimum phosphatase activity. This study suggested the possibility of a similar effect on the regeneration of bone. McKeown and Ostergren[2], Kamada[3], and the authors[8] have recently made phosphatase studies on fractured bones. Each investigator has reported an increase in phosphatase activity following fracture. McKeown and Ostergren believe that the increase is not confined to the fractured bones, but is somewhat generalized.

* Presented in part before the American Academy of Orthopaedic Surgeons, New York, N. Y., January 15, 1935.

The purpose of the present study was, first, to determine the effect of x-ray irradiation on the healing of fractures in adult bone by following the appearance of the fractures in roentgenograms made at regular intervals; second, to follow the course of the phosphatase activity of these bones at the site of fracture throughout the period of healing.

As a preliminary to the study of fractures, we treated the left forelegs of ten adult rabbits of the same pedigreed stock with 1,100 roentgens and sacrificed these animals at intervals up to sixty days. Phosphatase studies were made on the radii and ulnae. The findings are shown in Figure 1. It is quite clear that the phosphatase activity dropped off gradually, reaching a minimum value about three weeks after irradiation, and went up again within sixty days.

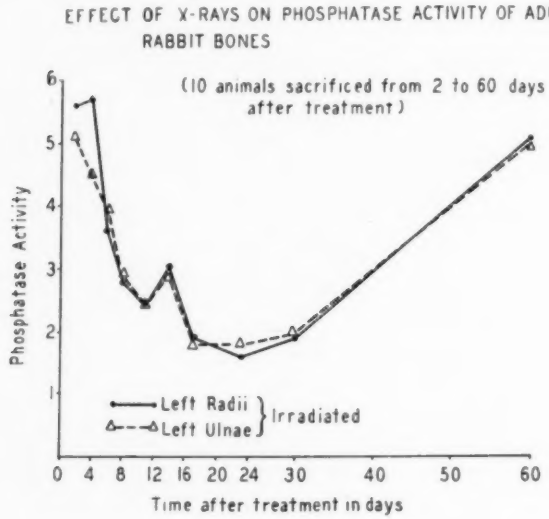

FIG. 1

We wished to produce fractures in a group of animals at a time when the phosphatase activity would be at a minimum and continue low for several weeks after fracture. In order to accomplish this, we treated eight adult female rabbits over the left forelegs with 1,112 and 622 roentgens* two weeks and one day, respectively, before producing fractures. On the basis of the previous findings shown in Figure 1, this treatment would maintain a low phosphatase activity in unfractured bones for at least four to five weeks. On the day after the second x-ray treatment, comminuted fractures were produced in both the experimental (irradiated) and control (unirradiated) ulnae of these eight rabbits, as well as in both ulnae of four control (unirradiated) animals. This was done by open operation in the manner described in a previous study [8]. The right ulnae of the treated animals, which had not been irradiated, were used as "semi-controls" and both ulnae of the four "control" animals were considered as "complete controls". Complete controls were used in order to detect any possible generalized effect of the irradiation on the factors under consideration. Roentgenograms were made

* The factors constituting the first dose (1,112 *r*) were: 200 kilovolts, 20 milliamperes, 60-centimeter target-skin distance, 0.25 millimeter of copper filter, and 20 minutes' exposure. The factors constituting the second dose (622 *r*) were the same as those given above, with the exception that the filter consisted of 1.0 millimeter of aluminum and 0.5 millimeter of copper.

of both forelegs of all twelve animals once each week. Eighty-eight pictures were taken, both forelegs of each animal being included on the same film. Thus, 176 observations were recorded, including two to fifteen pictures of each fracture. Throughout the period of observation all of the animals were kept under standard conditions at the registered rabbitry from which they were bought. The experimental animals were sacrificed at intervals of one to three weeks and the controls at intervals of two to six weeks. The bones were removed whole, carefully freed from soft tissue, and examined for size of callus and mobility. Sections, three centimeters in length and including the fractures, were then removed and weighed. These were cut into small pieces and extracted for seventy-two hours with twenty-five parts of water to which a few drops of chloroform had been added as a preservative. Phosphatase determinations were made on the filtrate from this material as described in a previous report [7].

Upon examination of the roentgenograms, a typical series of which is reproduced in Figures 2-A and 2-B, it was clear that there was in each case a marked delay in healing of the fractures in the irradiated ulnae as compared with the control bones. Figures 2-A and 2-B show the fracture in the control bone united after twenty-four days, whereas the fracture in the irradiated bone did not show union until the sixty-sixth day. A similar delay was present in each of the experimental animals. In one of the experimental animals, that shown in Figures 3-A and 3-B, the fracture in the control bone was united after thirty-eight days, while the fracture in the treated bone was still ununited when the animal was sacrificed on the 101st day. This marked delay suggests a possible permanent non-union.

Figures 4-A and 4-B show the progress of healing of the fractures in both ulnae of a typical control animal. It is clear that union progressed uniformly and was complete in both bones after thirty-one to thirty-eight days.

Examination of the bones after removal from the body and after cleaning showed that rigidity in both the semi-control and complete-control ulnae was attained well before that of the irradiated bones. By inspection also, the callus of the fractures in the experimental ulnae was in general found to be smaller than that of the fractures in the control ulnae, regardless of the time.

The values for phosphatase activity are given in Figure 5. In both the semi-control and complete-control bones, it is quite evident that the amount, or at least the activity, of this enzyme was greatly increased in the region of the fracture as compared with normal unfractured bone, reaching a high level within the first week after fracture before the appearance of any hard callous material. This is in agreement with a recent study [8] by the authors. The irradiated bones also showed an increase in phosphatase activity in the region of the fracture, but it is quite evident that this increase was not nearly as marked as that in the unirradiated bones. While the dose of x-rays employed reduces the phosphatase activity of bone, it is clear that it does not completely inhibit the increase

DELAYED UNION OF FRACTURE IN ADULT RABBIT FOLLOWING DEEP X-RAY TREATMENT (ANIMAL E-5)

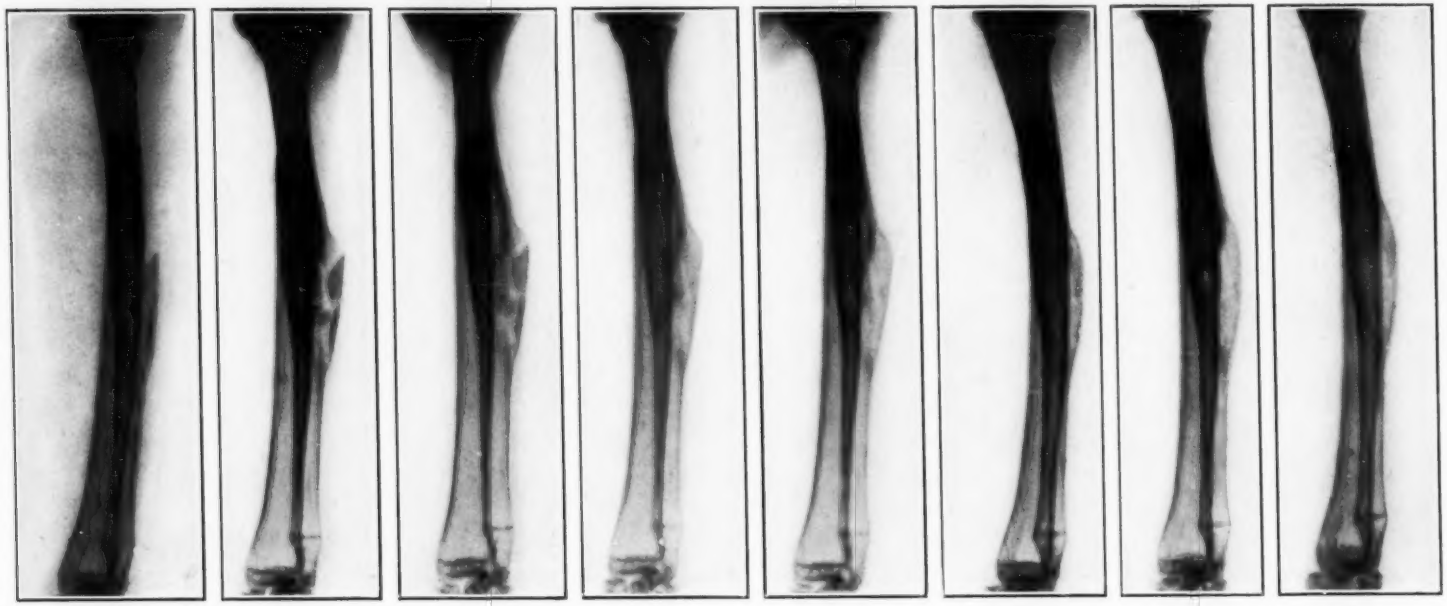

FIG. 2-A
Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

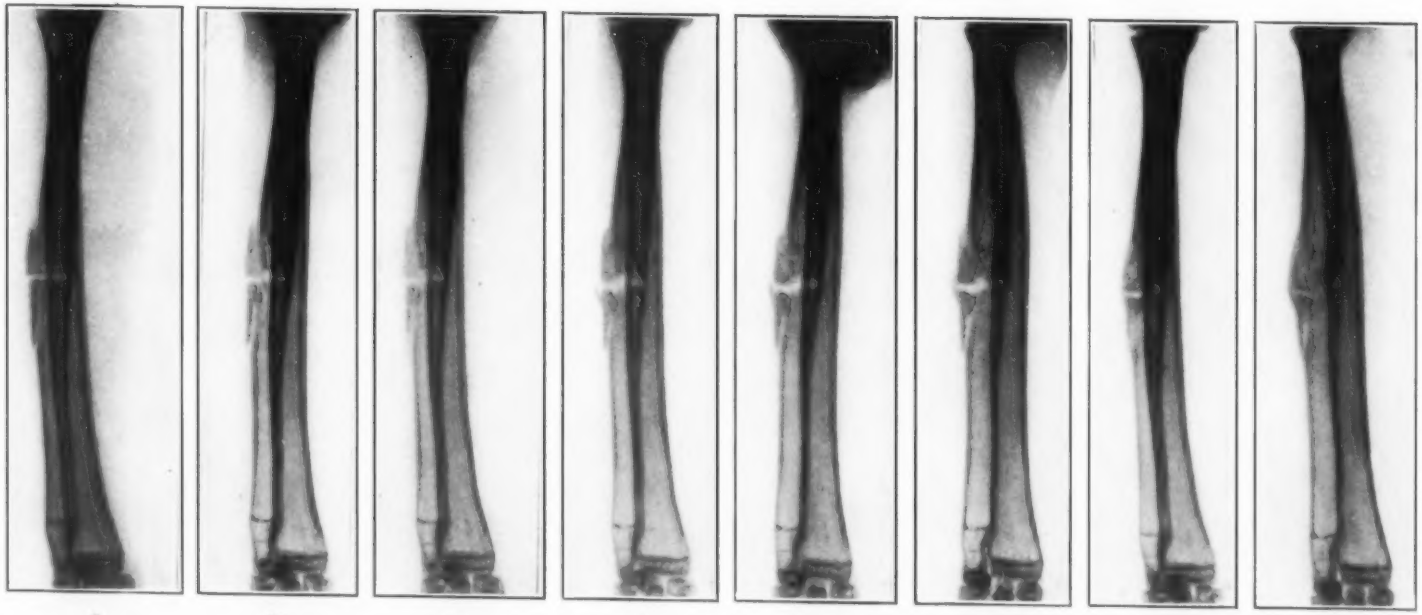

FIG. 2-B

Serial roentgenograms of left foreleg. Ulna fractured. Treated with 1,734 roentgens.

DELAYED UNION OF FRACTURE IN ADULT RABBIT FOLLOWING DEEP X-RAY TREATMENT (ANIMAL E-6)

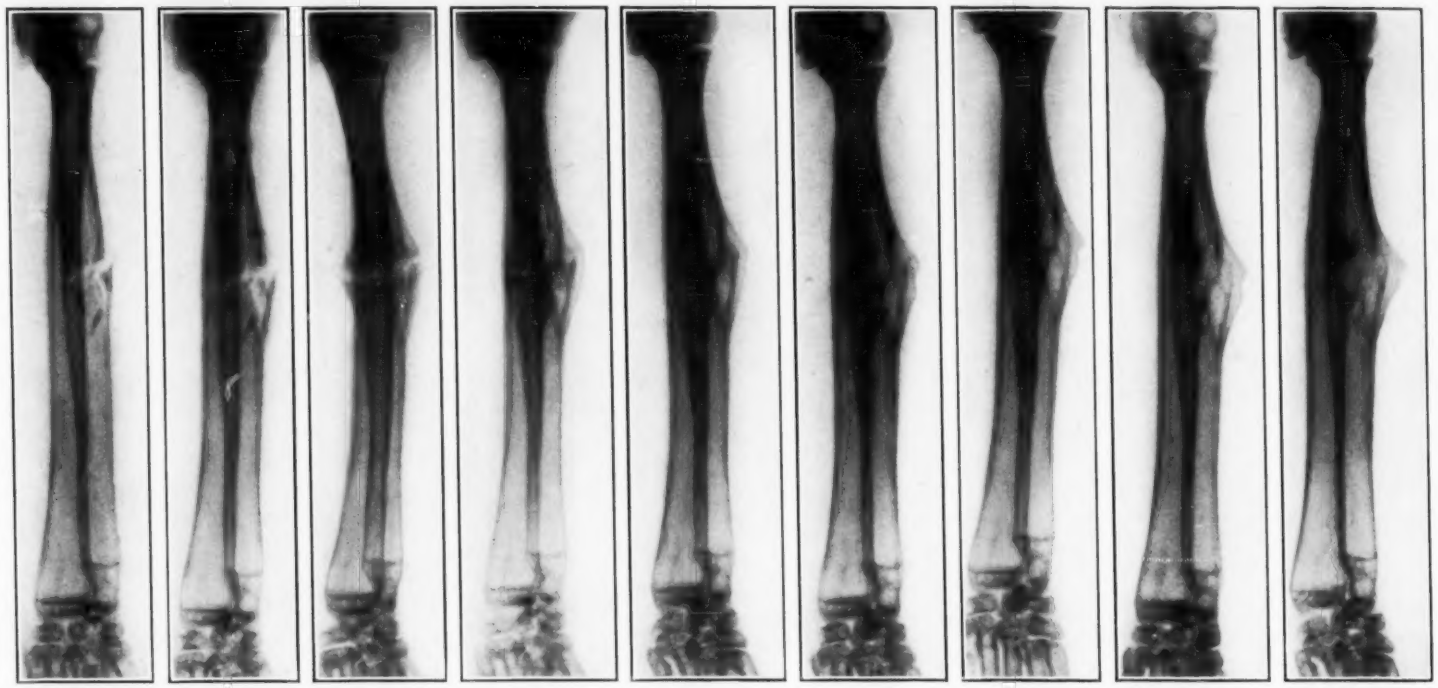

FIG. 3-A

Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

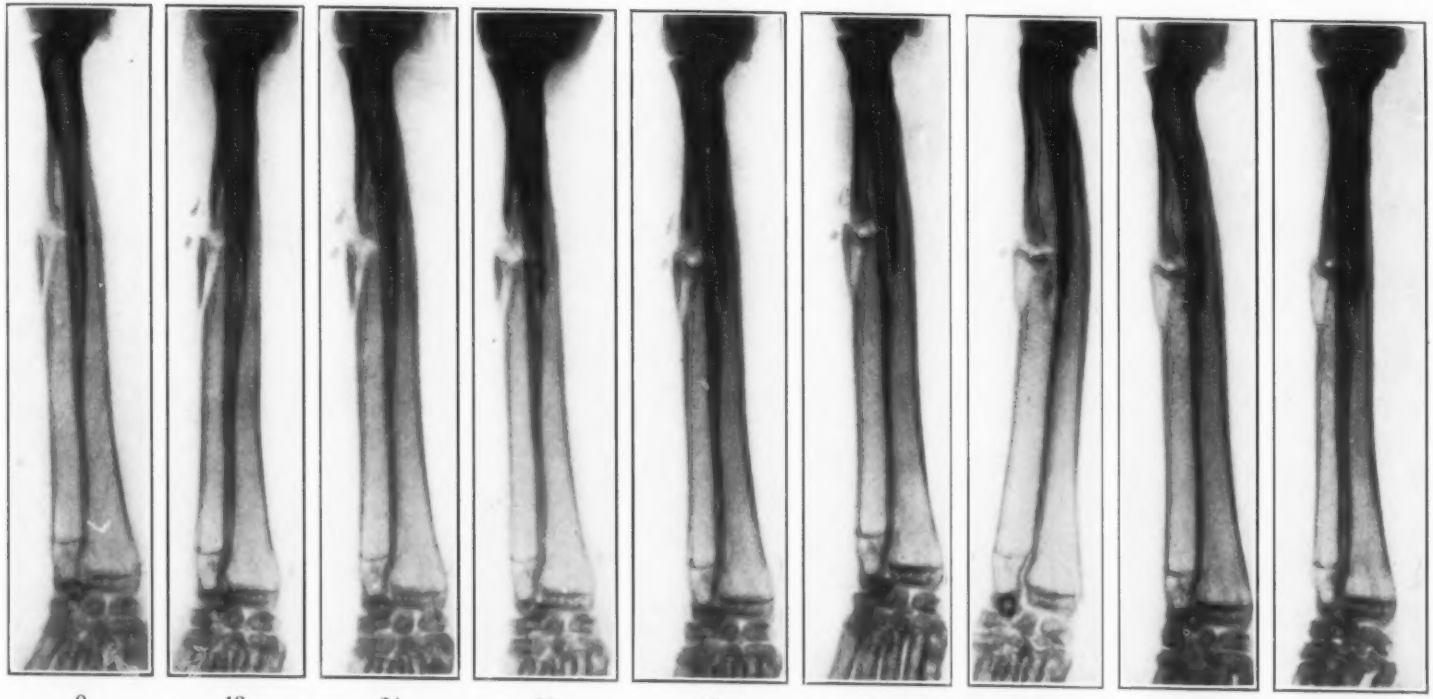

FIG. 3-B

Serial roentgenograms of left foreleg. Ulna fractured. Treated with 1,734 roentgens.

HEALING OF FRACTURE OF BOTH ULNAE OF ADULT RABBIT (ANIMAL E-11)

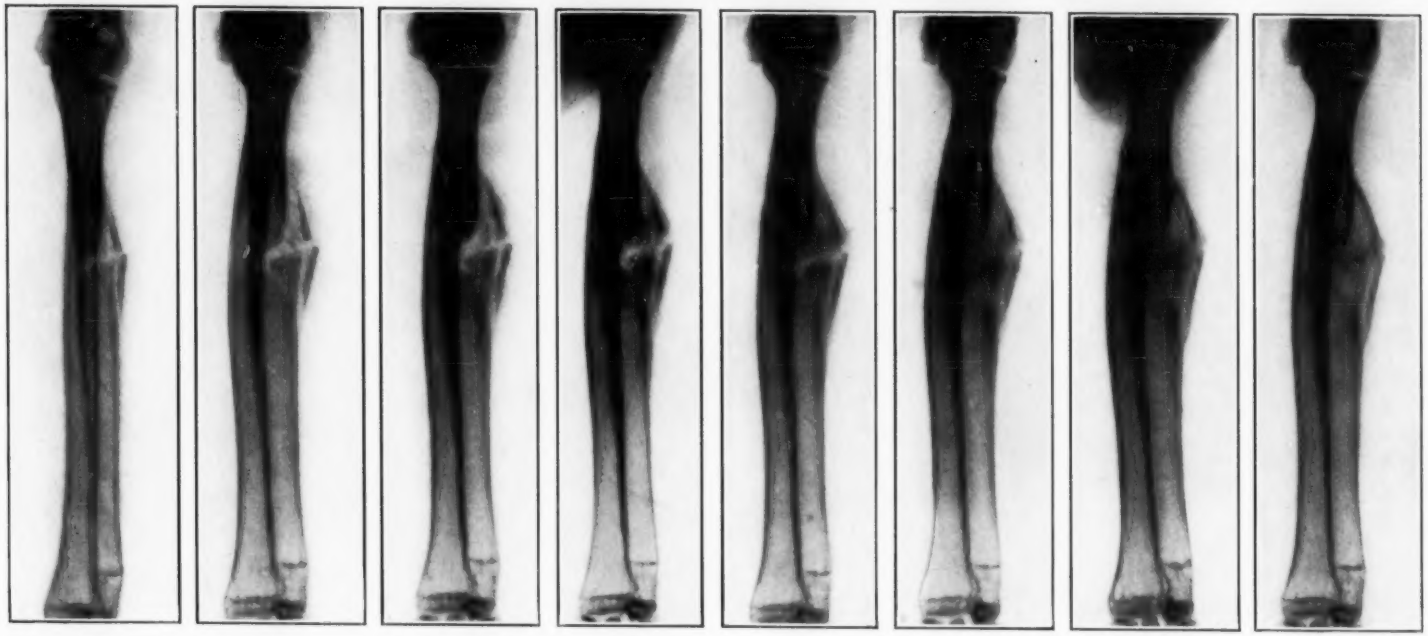

FIG. 4-A
Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

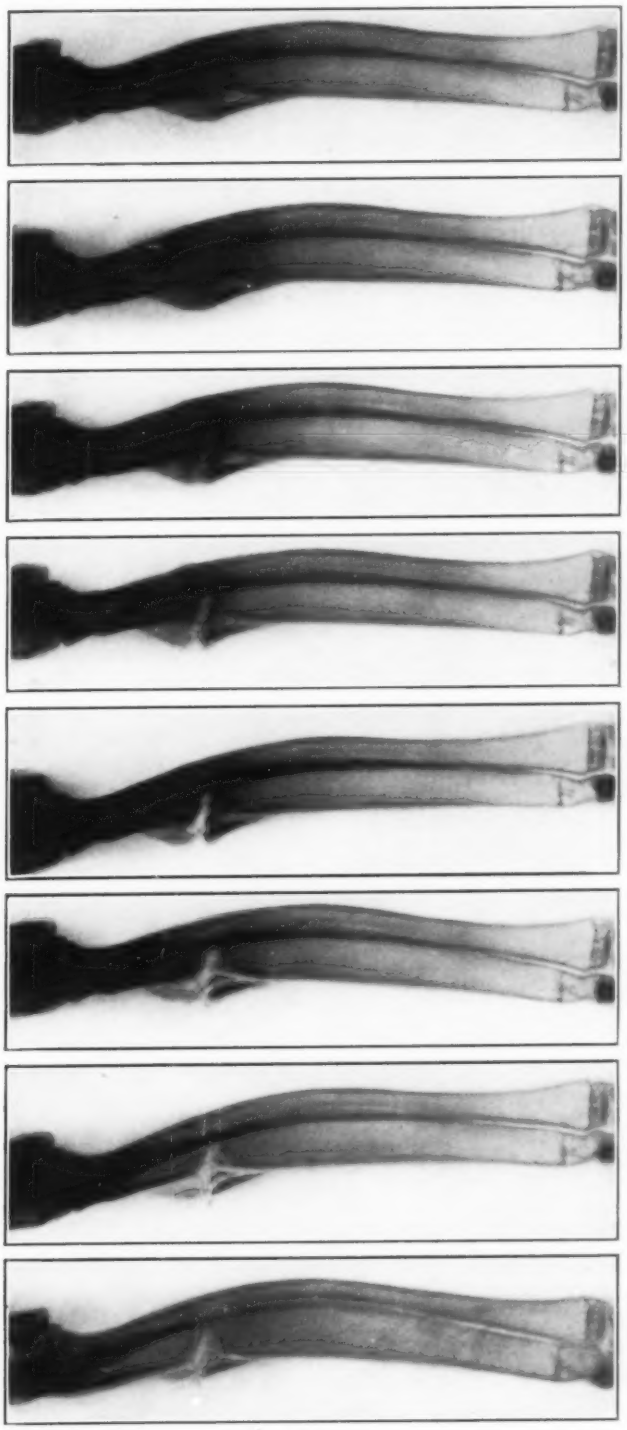

FIG. 4-B

Serial roentgenograms of left foreleg. Ulna fractured. No x-ray treatment.

in the enzyme that normally occurs in the healing of fractures. Thus, the fracture tends to increase greatly the phosphatase activity, while x-ray irradiation tends to inhibit this increase. By comparison of the roentgenograms with the phosphatase values, it is noted that the highest enzyme activity occurred within the period during which the first evidences of union were detected. This relationship lends further support to Robison's[4, 5, 6] theory regarding the rôle of phosphatase in ossification.

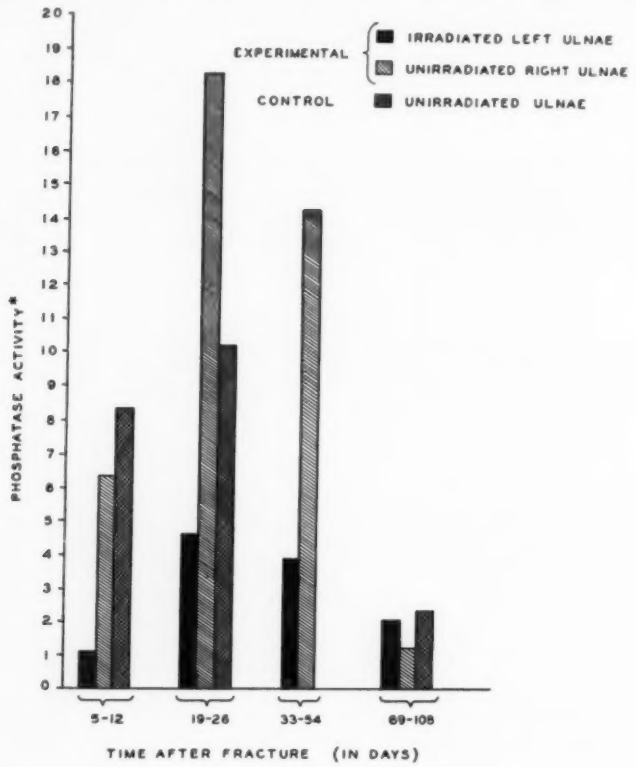

FIG. 5

The course of the phosphatase activity at the site of fracture of normal and irradiated bones.

* The phosphatase activity is expressed as the number of milligrams of inorganic phosphorus liberated per hour by the enzyme contained in the entire water extract of the sample from a substrate of sodium-Beta-glycerol-phosphate buffered with glycine-NaOH, at a pH of 8.8 and a temperature of 38 degrees, centigrade. The activity of the enzyme is calculated on the basis of the entire water extract rather than per unit of volume, since this is a better index of the amount of phosphatase present in the healing tissues.

A series of experiments similar to the foregoing is being carried out on seven litters of young rabbits, using litter-mate controls. The findings to date are essentially the same as those in the adult animals, with the exception that the fractures in both irradiated and untreated bones are healing more quickly than the corresponding groups in the adult series.

This, of course, is in agreement with clinical observations on the healing of fractures in children and adults.

CONCLUSION

Moderate doses of x-rays given previous to the production of fracture in adult rabbit bone result in marked delay of union and inhibition of the rise in phosphatase activity that normally accompanies the healing of a fracture.

NOTE: The possible clinical applications of the findings reported in these two papers is now being investigated. The results of this study will be given in a subsequent report.

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PREVENTION OF DEFORMITY IN ARTHRITIS*

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It is generally recognized that chronic arthritis is a constitutional disease, and that its treatment requires a great deal of concentrated care and study, in cooperation with the internist. From the point of view of orthopaedic surgery, we are primarily interested in seeing to what extent deformity can be prevented and how far the patient can be restored to a functionally useful life. In considering this problem, certain facts are accepted:

1. Deformity can be prevented;
2. Treatment requires time;
3. The result of after-care is the real test of orthopaedic success;
4. The postarthritic use of the body determines the future welfare of the impaired joint;
5. The freedom from recurrence depends on the health of the body and the lack of strain to the joint.

The question is: Can we by orthopaedic means return these patients to an active life, either well or restored to comparative usefulness? The author believes that the answer to this question is in the affirmative, provided that certain requirements can be fulfilled,—namely, early adequate treatment, cooperation between the medical and orthopaedic departments, cooperation of the patient, and conscientious follow-up. This last factor is as vitally important as early care. Many patients can be restored to functional activity, but they become careless and slip back because of their own neglect. It is the writer's belief that most of the serious deformities in arthritis are unnecessary if these desiderata can be secured. The final test of our work is the ability of the patient to live and work and move. During the months of treatment, we must be constantly preparing for the time when walking and the erect posture can be resumed.

It is not within the province of this paper to go into the details of how to make splints or to repeat the ground covered in the literature[1,2], although the methods of prevention are constantly improving, both from the non-operative and operative standpoints. It seems more important that emphasis be placed on the principles of prevention, so that each surgeon may work out his own method.

PREVENTION OF DEFORMITY

In the first place, most arthritic deformities are flexion deformities, resulting primarily from the necessity for muscular protection of a sore joint. Therefore, the time to prevent the deformity is before chronic

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 6, 1935.

spasm and contraction of the muscles have taken place and flexion has begun. The only way to prevent pain and muscle spasm and to secure rest is through fixation of a joint, the same principle which is carried out in the treatment of fractures.

There has been a superstition among laymen that one should "keep going"; that the joints should be moved in order to keep them from getting stiff. However, use of the joints is not permitted in any other inflammatory disease. Rest, then, is the first requirement for an inflamed joint, since it reduces pain and inflammation through removal of trauma, and with it the necessity for protective muscle spasm, and it effectively prevents flexion deformity of the joints. The best way to produce rest is by plaster casts applied to the extremities in such a way as to secure the best position for future use.

There is one factor which the writer feels is not sufficiently appreciated by most orthopaedic surgeons in treating arthritic joints,—namely, the fear which a sore joint produces in the mind of the patient, a mental complex of fear which overrules almost all other areas in life while it is present. The pain of a jar or motion in an inflamed joint is excruciating. It is not easily forgotten, and is partly responsible for many of the deformities. If this mental complex can be broken up by the knowledge that the jar and motion cannot occur after a cast has been applied, the patient relaxes all over and the process of building up is started. The elimination of fear gives that relaxation of mind which is exemplified many times by the confidence which the patients have in certain nurses and doctors.

The next point is: How long should these casts be used? It seems that the inflammation abates quicker with rest than it does without. The more complete the rest, the quicker the subsidence of the inflammation. Experience teaches that the slight traumata of use and motion do keep up the active arthritis. It has been the experience of most who have used protective splints in arthritis, both in this country and abroad, that it does no harm to keep a joint perfectly quiet in plaster anywhere from two to seven days. There is no danger of fibrous adhesions and permanent stiffness during this length of time. However, it is safe to make the rule that the cast be split at the end of two days and the joint inspected and passively moved as far as possible. This plan of daily inspection, daily motion, and observation of the reaction in the joint should be continued until the active inflammation seems to have subsided enough to allow for longer periods of freedom from complete rest. Sometimes this may take days, sometimes weeks. The principle of complete rest from weight-bearing activity should be continued until the time when the joint can be used quite freely. It has been the author's custom to continue the night rest indefinitely, as it eliminates fear of motion during sleep and consequent protective muscle spasm. Freedom from splints during the day allows activity and exercise either by physiotherapy or by occupational therapy. Even without motion of the joints, muscle training can go on. System-

atic education in the control of separate groups of muscles can be given, so that when use is permissible the muscles are already strengthened enough to carry out the desired motions. With this method of protection, adhesions are less apt to form and pannus is less liable to occur.

The use of these plaster casts requires a knowledge of the usual complications in arthritis and the ability to anticipate what is likely to happen. With the institution of this regimen before contractures have taken place, it has been the author's experience that a large number of deformities can be prevented. (See Figures 1 and 2.) It has been possible to cut down the number of operations performed for contraction deformities of the joints and to shorten the stay in the hospital for rheumatoid arthritics from fourteen months to a little over six months.

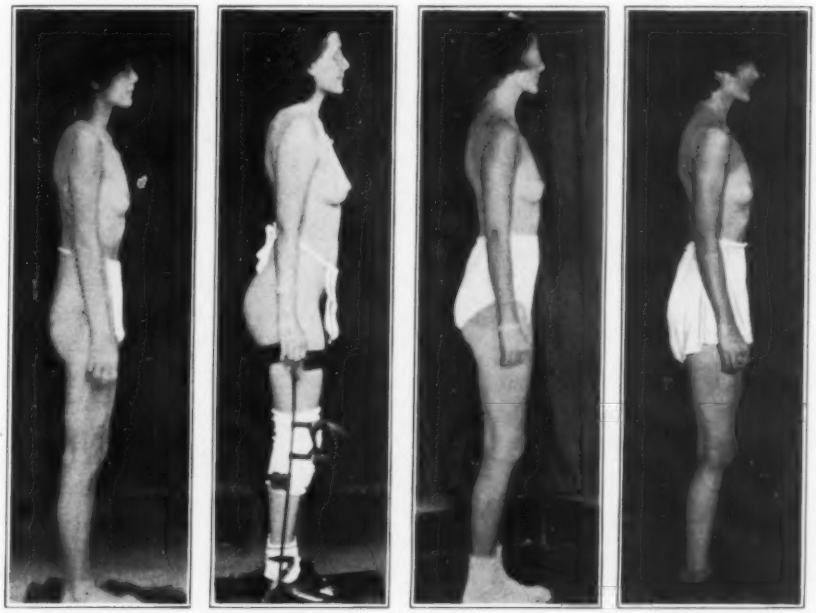
CORRECTION OF DEFORMITY

Non-Operative Procedure

The next procedure required of the orthopaedic surgeon is the correction of deformity by non-surgical means. It is interesting that the same principle of complete rest of the joint by protection with plaster casts works even when flexion contractures have already begun. Relaxation of the muscles which are causing flexion results in the immediate loosening of the flexion. Therefore, a plaster cast which has been left on a flexed knee for two or three days can be changed to a much straighter cast. In many of the contractions, this process of gradual correction by rest and relaxation is sufficient to overcome the deformity, so that surgical interference is not necessary. The prevention or correction of deformity without operation gives a better functioning joint than by operative measures, although surprisingly perfect results can be obtained by operation.

Manipulation

If, after conscientious use of plaster splints and mechanical stretching by apparatus such as wedge splints and calipers, the joint still continues to have limited motion, due to adhesions, and the deformity cannot be corrected, manipulative procedures are indicated in certain cases in which the arthritis is really quiescent. Manipulation should never be tried, however, during the active stage of the disease. It is well if manipulation can be avoided, because it is very apt to produce trauma and trauma causes more inflammation and a greater limitation of motion. However, in certain selected cases, manipulation of the knee has been quite successful in stretching tight muscles and the capsule and in breaking adhesions. The wrist is often successfully manipulated, as are the shoulders and feet. Manipulation of fingers and hips has not been found as successful as that of the other joints mentioned. Great care should be taken in manipulating the knees to use short leverage because the femur in an atrophic (rheumatoid) arthritic is liable to be easily broken because of the softness of the bones. Manipulation definitely has its place in the treatment of arthritis, but the cases have to be very carefully selected.



December 9, 1931 May 26, 1933 August 23, 1934 April 30, 1935

FIG. 1

A. H., aged 19, weighing 84 pounds, was admitted to Robert B. Brigham Hospital in December 1931, with rheumatoid (atrophic) arthritis of a year's duration. All joints were splinted and rested to prevent pannus formation and deformity while in bed. The disease ran a downhill course until November 1932, when gradual improvement began and continued under general medical care. The patient began walking in May 1933 with a caliper splint for the right knee and crutches. Note the hollow back, bad balance of the pelvis, and droop shoulders,—conditions which, if allowed to continue, would cause strain on the joints. By August 1934, the posture had improved with exercises and braces, and the joints were well enough to permit the supports and crutches to be discarded. There was no active arthritis, but an aeroplane splint was applied to the left shoulder to prevent contraction. In April 1935, the patient weighed 105 pounds; the posture was better; and, with the exception of some ankylosis of the fingers, there was full motion in all joints. The patient has been leading an active home life for a year and a half and there has been no recurrence of the arthritis.

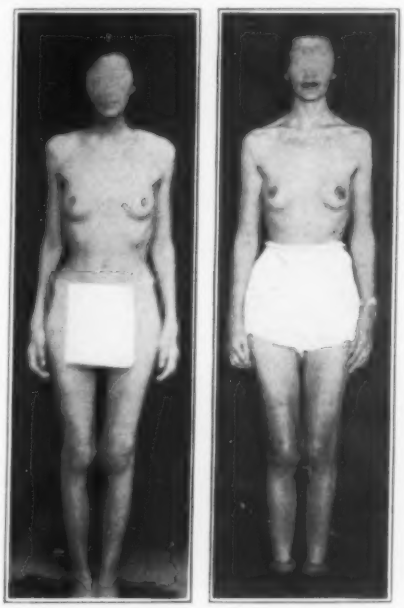


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FIG. 2

A. H., showing general improvement in four years.

Operative Procedures

What are the most successful operations which have been performed in the correction of deformities in arthritis? Operations on arthritic joints are no more hazardous than are those performed on any other type of joint. Apparently, the bones heal as well in arthritis as in other diseases, and there is no more danger of infection in opening an arthritic joint than in any other type of joint. The wounds also heal as easily. The joints which are most successfully operated on are the elbows and knees. (See Figures 3 and 4.) Operations on the shoulder, fingers, and hips have not been as successful.

Although some hands have been reconstructed by doing arthroplasties on the finger joints, really satisfactory hands have not resulted. Arthroplasties on the hip have been successful in but a very small percentage of the cases. The tendency to ankylosis is very great. Arthroplasties on the elbow give satisfactory results in practically all cases. Arthroplasties on the knees are successful in most cases, but there is the possibility of limited motion.

In knees which are flexed and have motion, with the patellae free, the posterior capsuloplasty, as developed by Wilson[3], has given the best results. In such cases, the posterior capsules are tight with adhesions, and the cutting of these adhesions is preferable to manipulation.

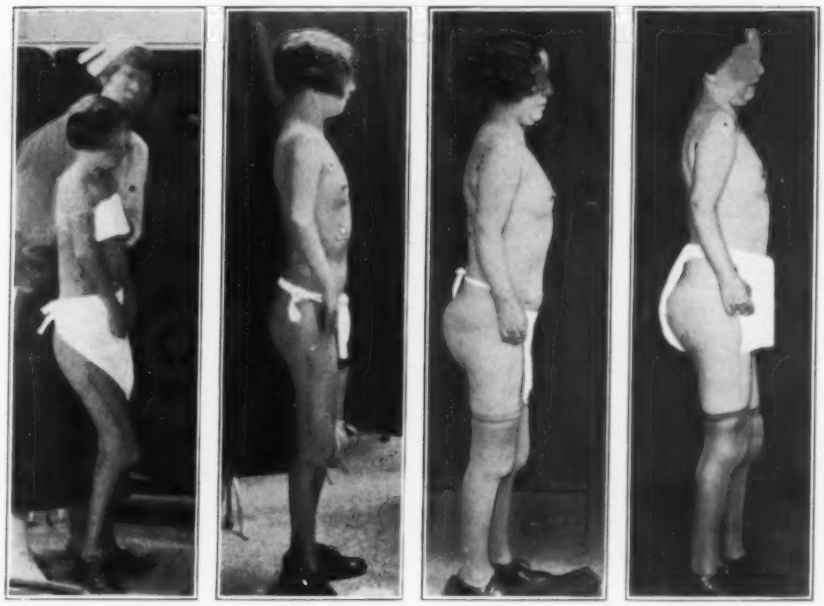
Another operation which has been successful in certain selected cases is synovectomy. Where the overgrowth of villous tissue has been considerable, particularly in the suprapatellar pouch around the patella, and where there is a good deal of pannus formation between the femur and tibia, the removal of this tissue permits free, painless motion of the knee. However, the cases have to be carefully selected and the after-care is important in order to prevent adhesions from forming and again restricting motion in the joints. If possible, this operation should not be done in the active stage of the disease.

Arthrodesis is an operation which in certain cases gives a stable knee or hip, making painless use possible. The aim of the orthopaedic surgeon, however, should be to secure motion whenever possible.

There are certain principles to be remembered in operating on arthritic joints. Motion should be started after the operation as soon as the soreness has gone. Therefore, arthritic joints should not be held long in one position. In order to prepare for this early motion, the muscles to be used in flexion or extension of any joint should be developed for a period of time before the operation. This is more important in securing a functionally useful joint than the actual technique of the operation itself. Operations should never be performed during the active stage of the disease.

AFTER-CARE

Strain from poor posture is quite capable of undoing much of the benefit of the preventive work on the knees and feet. Poor posture pro-



January 12, 1928 May 2, 1928 April 21, 1932 April 23, 1935

FIG. 3

L. V., aged 17, weighing 66 pounds, was admitted to Robert B. Brigham Hospital in November 1925, with rheumatoid (atrophic) arthritis of eight years' duration. She was bedridden and unable to stand or move. There was slight motion in the neck, back, right hip, shoulders, and knees; the rest of the joints were apparently fused. The patient's condition was built up by exercise, physiotherapy, and correction of posture and, in June 1927, an arthroplasty was performed on the right elbow. A similar operation was done on the left elbow in September 1927. Perfect functional results were obtained in both cases. In January 1928, the patient weighed 74 pounds and was ambulatory with a splint for the subluxated, outwardly rotated right knee. In November 1928, she weighed 84 pounds, and an arthroplasty was done on the right knee, following which she was able to walk with crutches. Arthroplasties on the third and fourth fingers of the right hand were done in April 1929, followed by an osteotomy of the left hip in September 1929. The patient was discharged walking in February 1930. Since then, there has been no active arthritis and the patient has full use of the elbows, neck, and back. She walks, does some light housework, and comes to the Out-Patient Clinic.

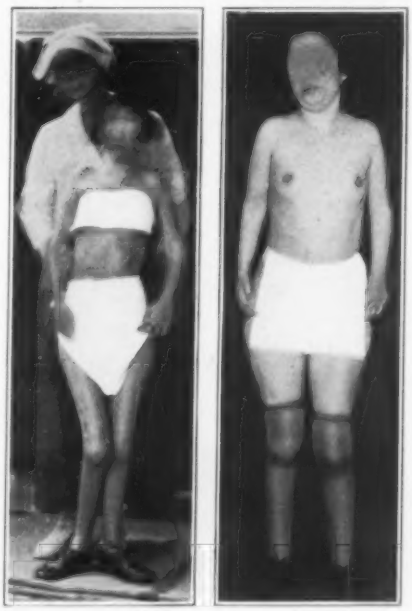


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FIG. 4

L. V., showing general improvement in seven years.

duces undue strain in standing and ultimately causes recurrence of inflammation in the joints which are subjected to this irritation. A lordotic back invariably strains hips and knees. It is important, therefore, to prevent this by careful physical training in the use of the body in bed and in sitting up before walking is allowed. Much time and suffering can be saved, and walking is made easier. Just as careful attention should be paid to the rebalancing and the after-training as is paid to splinting in the active stages of the disease. The future welfare of the patient depends on his learning to walk correctly with the least possible strain on the joints in order to prevent recurrences of inflammation and deformity. The meticulous care which is given during the years following the active arthritis really determines the ultimate success of the treatment. There can be no let-up in medical hygiene, diets, or physical training. Recurrence must be anticipated by warning the patient that he cannot take chances of lowering his vitality in any way.

Recurrences of the active disease and of deformity are too often the results of carelessness on the part of both patients and doctors, and of a reversion to old habits of living. It is the responsibility of the orthopaedic surgeon to be alert to this tendency to slump, and to prevent it. It is only in this way that deformity in arthritis can be prevented.

SUMMARY

1. The usual deformities attendant on arthritis result from flexion and are preventable if treatment by splints is begun early.

2. Correction of deformity is often possible by means of a series of splints.

3. Orthopaedic manipulation is sometimes successful in correcting contraction.

4. Operations such as arthroplasties, posterior capsuloplasties, synovectomies, and arthrodeses can be successfully employed in cases of chronic arthritis.

5. The patient must be so balanced as to posture that future strain will not cause recurrence of joint symptoms.

6. Until the patient is thoroughly trained in how to live, the aftercare for several years is perhaps the most important part of the treatment.

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FURTHER STUDIES OF FIXED PARALYTIC PELVIC OBLIQUITY *

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In a previous communication[2], the author stressed the importance of fixation of the pelvis in an oblique position as one of the major paralytic deformities. Depending upon the muscles involved, the obliquity may be divided into two main groups: first, that caused by an imbalance of the abductors and adductors of the thigh; second, that caused by an imbalance of the trunk muscles. The first type is also distinguished from the second by the fact that, when the contracture is limited to the abductors or adductors, the pelvic obliquity can be overcome with the patient in the recumbent position by swinging the legs to one side or the other. If, however, the trunk muscles are responsible for the obliquity (second type), the pelvic tilt persists even in the recumbent position irrespective of the position of the legs. The kinesiological pathology causing the first type of fixed paralytic pelvic obliquity is easy to understand, and its treatment is equally simple. Division of the tight abductor or adductor structures, coupled with a simple fascial transplant, has thus far in a group of carefully followed cases given complete, permanent correction of the pelvic obliquity. The second group, however, represents a far more complicated and difficult problem. It is with these obliquities, due to imbalance of the trunk muscles, that this paper deals. Both in the accurate diagnosis and in the effective treatment, these cases present many unsolved problems which challenge the ingenuity of the orthopaedic surgeon.

Just as in the first group the femur must be thought of as balanced by the opposing action of the abductors and adductors, so in the second group the pelvis must be thought of as balanced by the opposing action of certain trunk muscles, particularly the quadratus lumborum, the obliquus externus abdominis, and the obliquus internus abdominis (Figs. 1 and 3). The sacrospinalis and longissimus dorsi also play a rôle, but, owing to their location close to the midline, their leverage action in causing a tilting of the pelvis is less than that of the muscles lying in a more lateral position. The quadratus lumborum, the obliquus externus abdominis, and the obliquus internus abdominis are powerful flexors of the trunk when the pelvis is held immobile. Conversely, if the dorsal spine and the thorax are held rigid, they tilt the pelvis, an action which can be observed to particular advantage in certain oriental dances. These muscles must, therefore, be reckoned not only as lateral flexors of the trunk, but as lifters of the pelvis.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

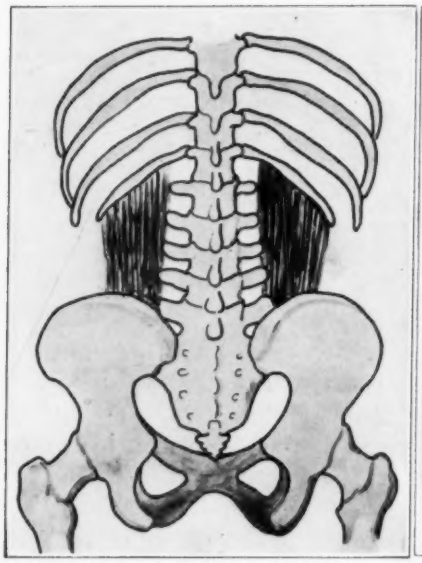

FIG. 1

Diagrammatic representation of the action of the quadratus lumborum muscles. When equal in strength, they help to maintain the pelvis in a horizontal position.

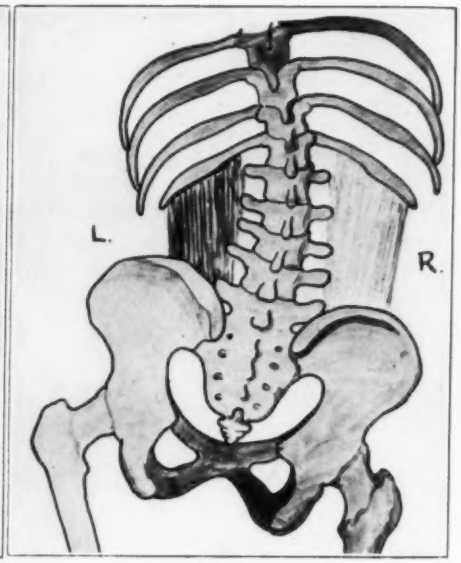

FIG. 2

Effect of paralysis of the right quadratus lumborum. Owing to the weakness of this muscle, the pelvi drops on the right side and the opposite quadratus contracts, thus holding the pelvis in an oblique position.

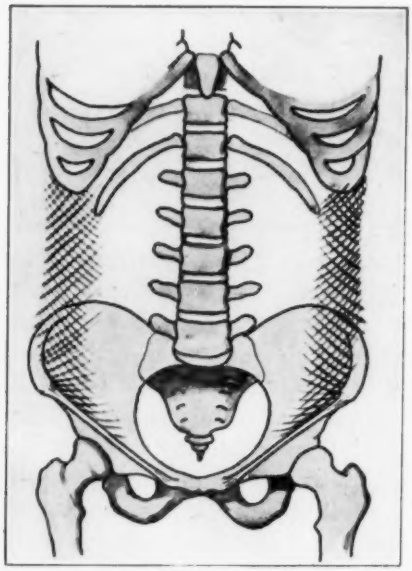

FIG. 3

Diagrammatic representation of the action of the external and internal oblique muscles. When equal on both sides, they, like the quadratus lumborum, help to hold the pelvis in a horizontal position.

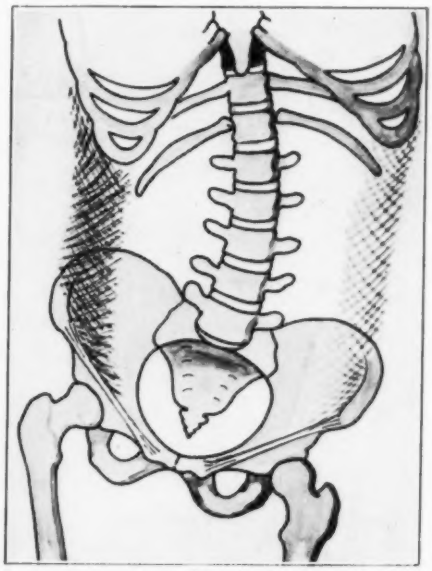

FIG. 4

Diagrammatic representation of the effect of paralysis or weakness of the external and internal oblique muscles of one side. The pelvis drops on the paralyzed side and the strong muscles contract, holding the pelvis in an oblique position.

Were it not for them, locomotion would be difficult, since they act with the abductors of the opposite hip to lift the pelvis of the swinging leg at each phase of the stride. If, however, as a result of infantile paralysis, the quadratus lumborum and the obliqui abdominis of one side become paralyzed, the opposing muscles of the opposite side will be permitted an undue range of contraction,—the pelvis will drop on the affected side and be lifted on the opposite side, resulting in the development of a scoliosis with its convexity toward the paralyzed side (Figs. 2 and 4). Beginning as a barely perceptible pelvic tilt, the deformity will, if unchecked, develop until one hip is three or four inches higher than the other; the spine becomes fixed in a scoliosis of such extreme degree that compensation is impossible and the body tilts far over toward the short leg. Locomotion becomes almost impossible. Frequently, secondary deformities of the hip and knee develop, the most common being an upward subluxation or dislocation of the hip on the short side and a hyperextension of the knee on the long side.

FIG. 5

Test for the action of the quadratus lumborum. As the patient pulls up—first on one side, then on the other—the examiner resists the motion by pulling downward on the ankles and thus is able to test the relative strength of the two muscles. This is not a pure quadratus action since the obliqui abdominis and the sacrospinalis also participate. By palpating the quadratus, additional information can be secured.

Warned by the pathetic picture presented by patients in these late stages, we have tried to diagnose this condition at its inception. This can be done only by demonstrating loss of power in the quadratus and the obliqui abdominis. The test for the quadratus which we have found most reliable is illustrated in Figure 5. With the patient

FIG. 6

The blowing test for the abdominal muscles. If there is a localized weakness of the abdominal muscles, a bulging will be noted, as indicated on the left side of the abdomen. This patient had only slight pelvic obliquity, owing to the presence of a strong quadratus on the left side.

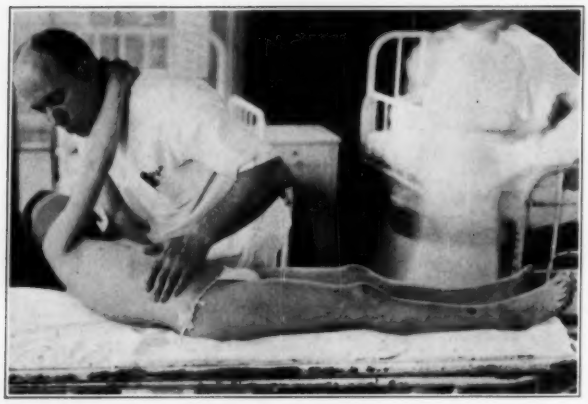

FIG. 7

Testing the strength of the lateral abdominal muscles. The patient, lying supine, grasps the examiner about the neck, thus lifting the body clear of the examining table. The body is brought far to one side and the patient is then asked to swing the body back to the neutral position. As this action is performed, the abdominal muscles are palpated by the physician. When the test has been done for the muscles of one side, the examiner moves to the opposite side of the table in order to test the opposite group of muscles.

in the supine position, the physician grasps both ankles and instructs the patient to pull up first one side of the pelvis, then the other. Of course other muscles besides the quadratus are concerned in this movement, but, by palpating the quadratus muscles during the manoeuver, much can be learned about their relative strength.

Lowman's tests for the lateral abdominal muscles are of great value and, in addition, the following methods may be employed. The patient is asked to blow out his abdomen as much as possible. If the lateral abdominal muscles are weak, they will balloon out, as shown in Figure 6. Next, the patient, lying supine, clasps the examiner with both hands (Fig. 7), thus lifting himself clear of the examining table. The physician flexes the patient's body toward the side, and then requests the patient to try to swing the body back to the neutral position. As this is done, the physician palpates the lateral abdominal muscles. The examiner then shifts to the opposite side of the table and repeats the test for the opposing muscles.

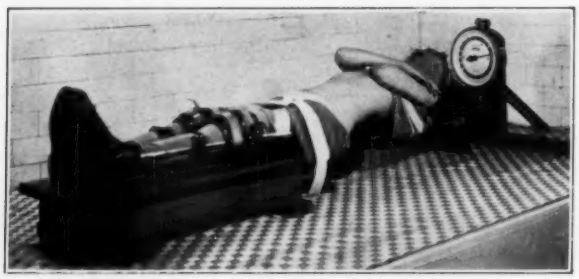

FIG. 8

Apparatus for registering in pounds the strength of the lateral abdominal muscles. The upper half of the wooden frame on which the patient is strapped moves freely on a pivot located beneath the sacrum. Lateral motions of this freely moving platform are transmitted by ropes running over pulleys to a spring balance which registers in pounds the force of the motion. This may also be measured by attaching a spring balance to a hook placed in the side of the wooden platform.

Since these tests, like most muscle examinations, have only relative accuracy, we have tried to measure the pull of the lateral flexors of the trunk by means of a spring-balance apparatus (Fig. 8). This consists of a wooden plat-

form mounted on a pivot so that it can swing easily from one side to the other. The patient's trunk is strapped securely to this platform, the legs being supported on a fixed board. As the patient contracts the lateral abdominal muscles—first of one side, then of the other—he swings the movable platform to and fro, the force of this motion being registered in pounds on a spring balance connected to the platform by cords running over pulleys. Another method, similar to the Lovett spring-balance tests, is to attach the spring balance to a hook on the side of the platform and to take a reading at the maximum degree of tension exerted by the patient.

Despite these studies, we are more than ever impressed with the inadequacy of the methods of testing the strength of the trunk muscles. One purpose of this paper is to stimulate further work on this important phase of pathological kinesiology.

FIG. 9

Photographs of a child with pelvic obliquity, due to weakness of the left obliqui abdominis and left quadratus. The left-hand figure illustrates the condition two months after the onset of infantile paralysis. The right-hand figure indicates the condition after two years of thorough non-operative treatment. Despite this, the muscle imbalance caused an immediate return of the obliquity as soon as the corrective apparatus was removed.

Inaccurate though these methods have been, they have enabled us to detect weakness of the quadratus and the obliqui abdominis in a number of early cases of poliomyelitis. If this weakness is unilateral, a pelvic tilt has always been present. Figure 9 illustrates such a case. The left-hand photograph shows the patient eight weeks after the onset of the poliomyelitis. The left obliqui abdominis and the left quadratus were markedly weaker than the right; consequently, the right side of the pelvis has been pulled upward and a pelvic obliquity is present. This patient was treated conservatively for almost two years by the "push-and-pull" method. The right leg was pulled down and the left leg was shoved up (Fig. 10); yet, each time the traction was removed, the deformity returned within a few hours. The right-hand photograph, showing the patient two years later, illustrates the ineffectiveness of such non-operative treatment in the presence of a persistent inequality in the strength of the opposing trunk muscles.

Having been taught by several such cases, we decided in the case of the next patient who came under our treatment not to wait until the conventional two-year period had elapsed, but, as soon as we were convinced of a serious imbalance in the action of the trunk muscles, to correct this by operation. In devising an effective procedure, we were greatly helped by the pioneer work of C. L. Lowman [1] who demonstrated the value of fascial transplants in the correction of weak abdominal muscles. For the purpose we had in mind,—namely, the lifting of one side of the pelvis—it seemed to us inadvisable to follow Dr. Lowman's technique, but, rather, to run the fascial transplant from bone to bone,—from the ninth rib to the iliac crest. We felt that in this way the dropping of the weak side of the pelvis could probably best be prevented.

FIG. 10

The "push-and-pull" apparatus used in non-operative correction of pelvic obliquity. The short right leg is being pulled downward by a ten-pound weight; the long left leg, encased in plaster-of-Paris to support the knee, is being shoved upward by a powerful spring encased in a wooden box.

The operation consists of the following steps:

1. A transverse incision, four inches long, is made following the course of the ninth rib from the anterior axillary line to the sternum. The rib is exposed for a distance of two inches and is denuded of periosteum. A silk guide suture is then passed about the rib and the loop of the suture is left projecting from the lower surface. This is done so as to permit the fascial graft to be carried completely around the rib. The fascia in the region of the sternum is slit for a distance of two inches to allow the attachment of the inner tail of the fascial graft (Step 4).

2. A four-inch incision is made along the course of the ilium from a point three inches back of the anterior-superior spine to a little below the origin of Poupart's ligament. The crest of the ilium is split off for a distance of three inches, thus forming an osteoperiosteal flap to which the fascia lata is still attached.

3. A broad tunnel is now made, connecting the first incision with the second. This tunnel runs through the subcutaneous tissues just superficial to the abdominal fascia. It must be at least three inches wide throughout its extent. It is best made with a strong clamp and then widened by the fingers of the operator. If there are any bleeding points, they must all be caught and clamped. This can be done by lifting up the skin of the abdomen with long retractors. Two guide sutures are passed

through this tunnel,—one on the mesial side and the other on the lateral side.

4. Through a lateral incision, extending the entire length of the thigh, a strip of fascia lata is removed. This must be sufficiently long to reach from the iliac crest up to and around the ninth rib. It must be at least three inches wide and at one end should be slit so as to form two tails,—one for the rib attachment and the other for the sternal attachment.

5. The strip of fascia lata is drawn through the abdominal tunnel by means of traction sutures which have been caught in the two guide sutures during the third step of the operation. Great care must be taken that this strip does not twist, but remains flat. The fascia is fastened first to the crest of the ilium and Poupart's ligament by a series of No. 1 chromicized gut sutures. A second series of sutures is taken, bringing the osteoperiosteal flap back into its original situation. Thus, the fascia is fastened to the bone by means of a double series of sutures. Fixation must be secure enough so that eight or ten pounds of force may be applied to the fascia without disturbing its attachment. The upper end of the fascial transplant, which has been split longitudinally into two halves for a distance of three or four inches, is then sutured. The lateral half is drawn about the rib by means of the guide suture previously placed during the first step of the operation. While an assistant pushes up strongly on the pelvis and another assistant exerts lateral pressure on the body of the patient so as to approximate the ribs and the pelvis to the maximum on the affected side, the fascia which has been drawn about the rib is fastened to itself by three or four chromicized gut sutures. The mesial tail of the fascia is then fastened under strong tension to the fascia close to the sternum. When this step of the operation has been completed, the fascia should be felt as a tight band extending from the crest of the ilium up to the ninth rib. A half dozen additional sutures are taken to the margins of the fascial transplant, uniting these to the abdominal muscles in such a way as to keep the fascia as broad as possible and in the most intimate contact with the abdominal muscles. All incisions are then closed.

FIG. 11

H. A., a patient with paralytic obliquity, due to weakness of right obliqui abdominis muscles and right quadratus. Despite non-operative treatment for a period of six months, the right side of the pelvis dropped as soon as the corrective apparatus was removed. A fascial transplant was done February 21, 1934. Photograph shows the result approximately one year after operation. The pelvic obliquity has not recurred, and the patient walks with only a slight limp.

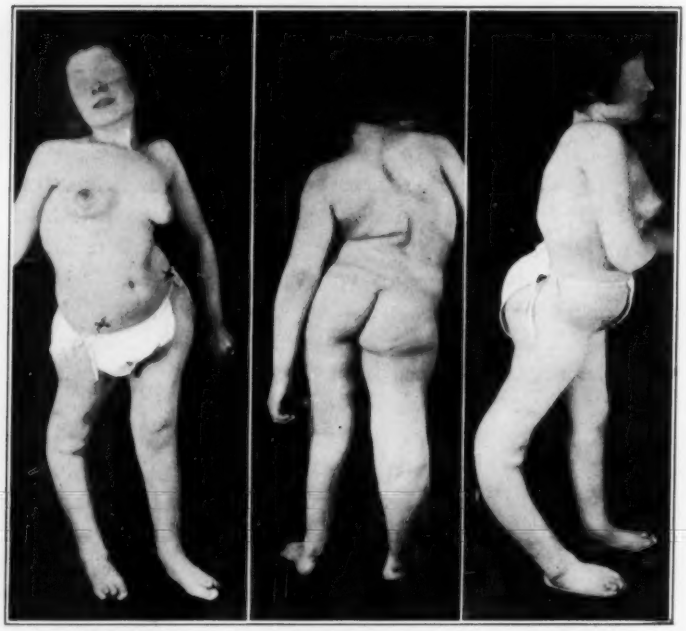

FIG. 12-A FIG. 12-B FIG. 12-C

R. R., before treatment, showing fixed paralytic pelvic obliquity, right lumbodorsal scoliosis, and recurvatum of the right knee.

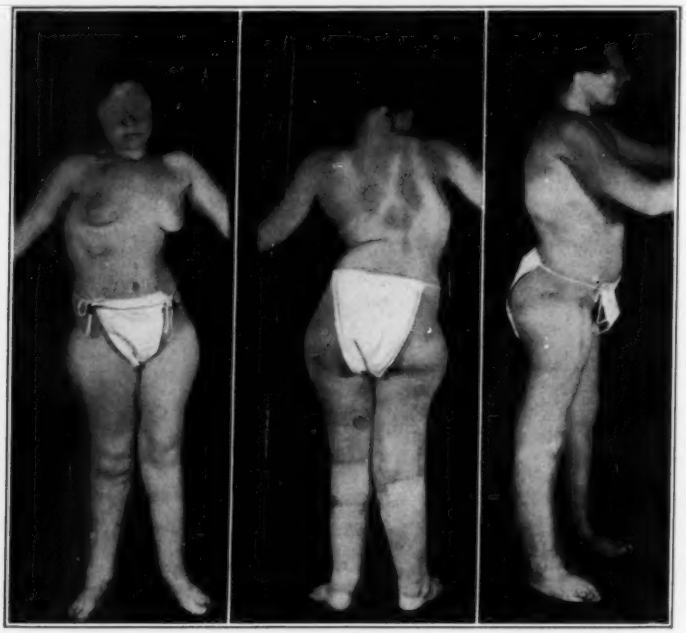

FIG. 13-A FIG. 13-B FIG. 13-C

R. R., after six months of treatment. The following operations had been done:

1. Division of spinal ligaments ("spinal release");
2. Fascial plastic for the paralyzed right abdominal muscles;
3. Bone-block operation for recurvatum of right knee. Note the correction of the pelvic obliquity and the recurvatum and the improvement in the scoliosis.

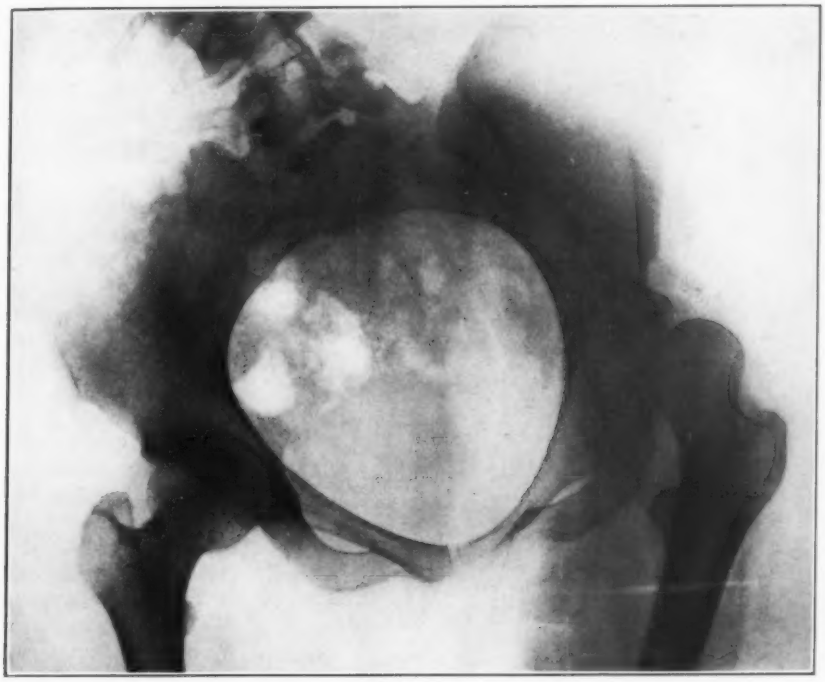

FIG. 14

Roentgenogram of patient R. R. at time of her admission, showing the pelvic obliquity and the subluxation of the left hip.

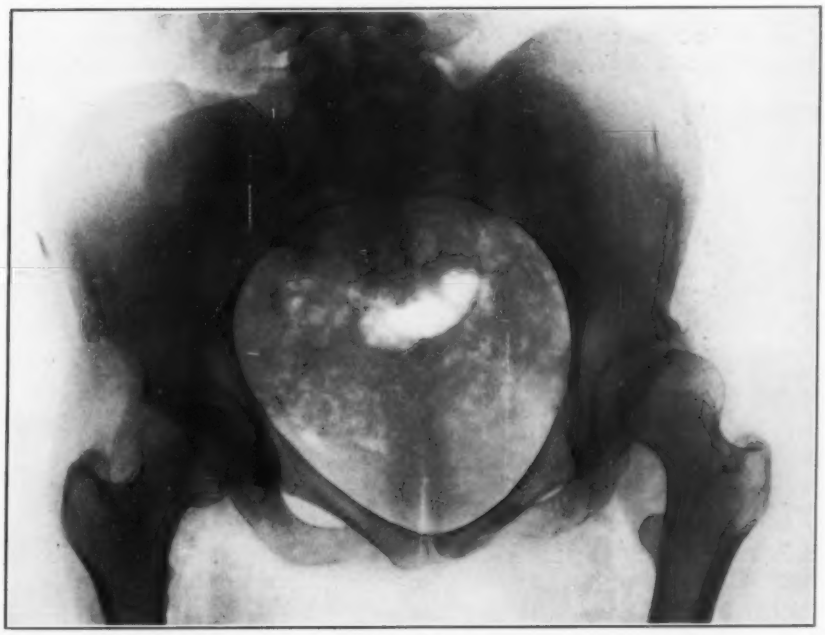

FIG. 15

Roentgenogram of pelvis of patient R. R. after six months of treatment.

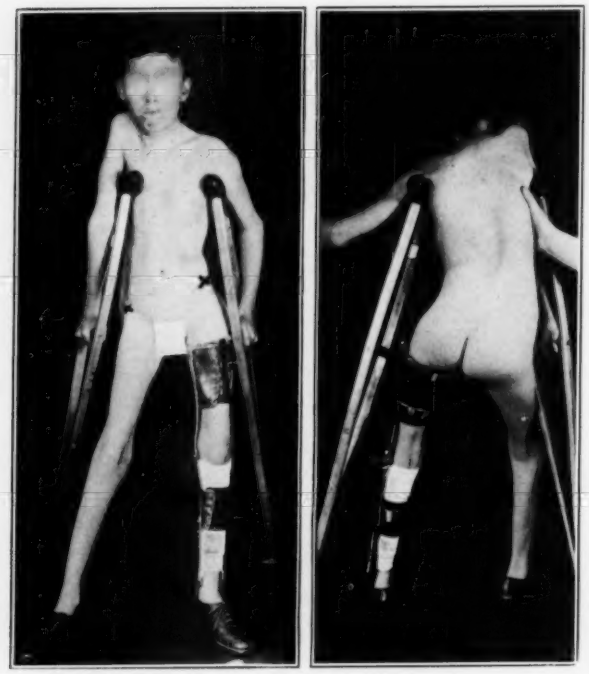

FIG. 16

J. R. at the outset of treatment. Note the pelvic obliquity, the severe right lumbodorsal curve, and the obvious difficulty in maintaining balance.

The effect of the operation in the following early case of pelvic obliquity has been most gratifying.

H. A., a male, aged twenty-two, was admitted to the Hospital for Joint Diseases suffering from poliomyelitis in a subacute stage. The onset had occurred seven weeks before admission. The striking feature of the case was the marked weakness of the right quadratus and the right obliqui abdominis. This showed itself by a downward tilt of the right side of the pelvis.

By applying traction to the left leg and an upward push to the right leg, which had been encased in plaster-of-Paris, it was possible to keep the pelvis horizontal. However, after six months in bed, the marked imbalance in the action of the trunk muscles was still present. When the patient was allowed to get out of bed, the pelvic tilt became evident not only when

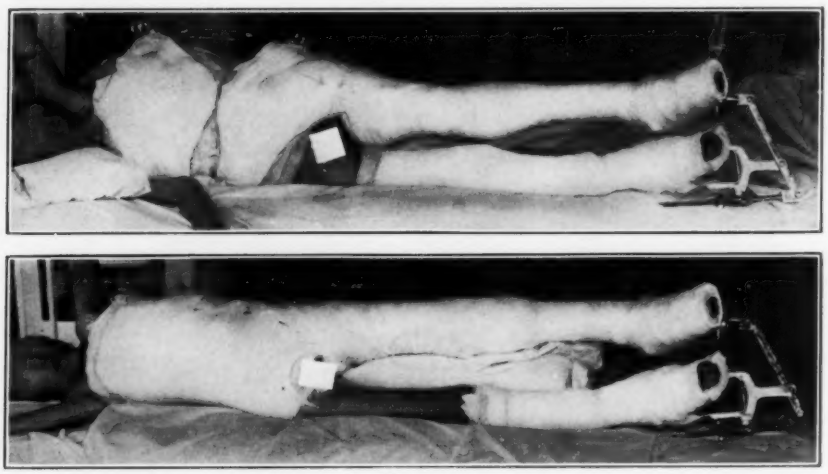

FIG. 17

J. R., showing correction of pelvic obliquity by means of the Roger Anderson traction splint. This had the double effect of pulling down on the short left leg and pushing up on the long right leg. The upper photograph shows the additional correction of the scoliosis by means of the turn-buckle jacket.

standing still, but even more when the patient tried to walk. It was then noted that, despite the good left gluteal muscles, he could not advance the right leg because the pelvis dropped on the right side. The fascial plastic operation was then performed in which the fascial grafts ran from the right ninth rib to the right iliac crest. The result nine months after the operation is shown in Figure 11. There has been no return of the pelvic tilt and the patient walks remarkably well considering the degree of his paralysis.

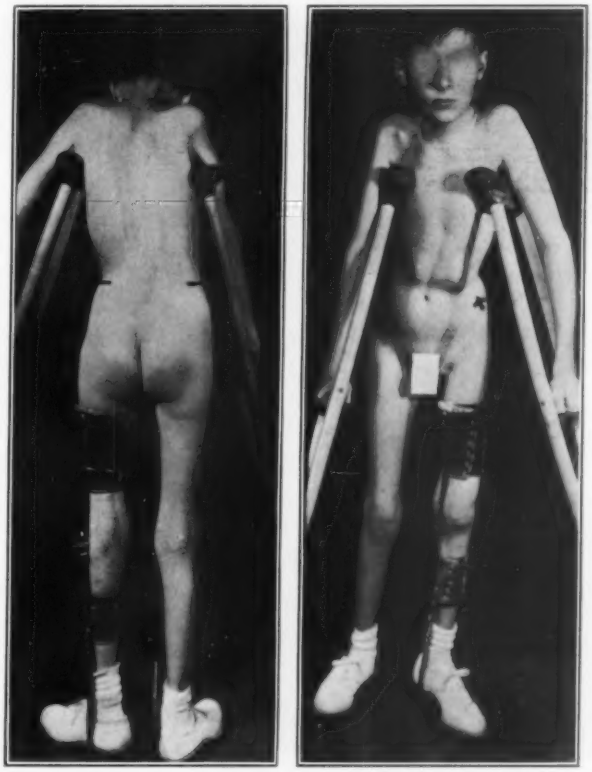

FIG. 18

J. R., after four months of treatment. The following operations had been done:
1. Division of spinal ligaments ("spinal release");
2. Fascial graft for paralyzed right abdominal muscles.

No deformity of the rib has developed in this case or in the fifteen other cases in which the same technique was employed.

The late cases of pelvic obliquity, due to imbalance of the trunk muscles, present at first sight an almost impossible therapeutic problem. The pelvis tilts at an angle of 20 to 50 degrees, making one leg two to four and one-half inches longer than the other. The spine is fixed in a curvature so extensive as to baffle correction by any method heretofore devised. The majority of patients who came to us had been under treatment in clinics of recognized standing and yet these terrifying deformities had been allowed to develop under the eyes of the attending surgeons who apparently had satisfied their therapeutic urge by performing astragalectomies or similar equally ineffective operations in no way connected with the all-important pelvic problem. Most of these patients were unable to walk; they could just balance in the standing position by hyperextending the long leg (Figs. 12-A, 12-B, and 12-C) or by holding it in marked abduction. Two patients wore spinal braces which were obviously ineffective. Of course, no brace could possibly give support to such a markedly decompensated scoliosis as that depicted in Figures 12-A, 12-B, 12-C, and 16.

The picture was all the more pathetic when illuminated by the fact that all this deformity could have been prevented by adequate treatment

in the early stage. Orthopaedic surgeons must realize that a fixed pelvic obliquity is one of the most crippling of the paralytic deformities and that, like equinus, knee contracture, or drop wrist, it can be prevented from developing.

But what is one to do in the cases in which this deformity is already present? Our method has been the following:

First, traction is applied to the short leg. This can best be done either by the Roger Anderson splint (Fig. 17) or, in the worst cases, by skeletal traction.

Traction alone, however, is not sufficient; the contracture between spine and pelvis should be released and the scoliosis, if not cured, at least should be reduced to a reasonable degree of compensation, permitting resumption of the upright position. In two cases, traction to the trunk, followed by application of lateral-flexion turn-buckle plaster corsets by the Hibbs method, gave fair correction. In the other cases, an operation which the author terms "spinal release" was done. By means of this procedure, the lumbar spine, sacrum, and high side of the pelvis are exposed. Every accessible spinal ligament is cut,—the ligamenta interspinalia, the ligamenta subflava, and the capsules of the intervertebral articulations. Particular care is taken to free the lumbosacral liga-

FIG. 19

Roentgenogram of patient J. R., indicating the pelvic obliquity and the right lumbodorsal scoliosis. For clarity in reproduction, the iliac crests have been retouched.

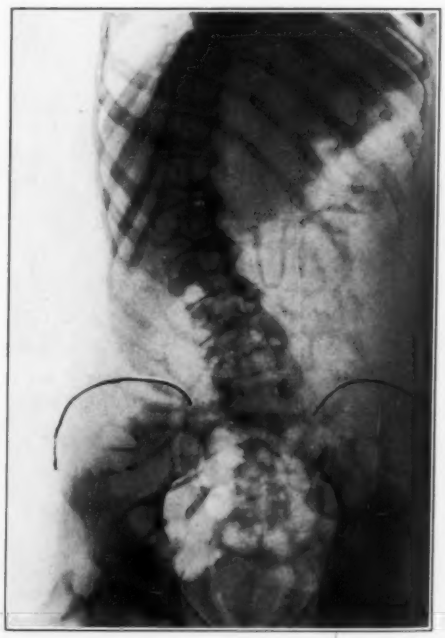

FIG. 20

Roentgenogram of patient J. R. after six months of treatment.

ments on the low pelvic side as well as on the high pelvic side. Unless this is done, it is impossible to swing the spine out of its deformed position. One must be extremely thorough and at the same time not perforate the dura. This trauma can occur so easily that the author has devised a special instrument—a chisel with a shoulder one-fourth of an inch from the cutting edge—which will not slip and cut the dura as the ligamenta subflava are cut. Although we have also divided the fascia and muscles of the concave side of the curve, this has apparently not aided materially in the correction. Thus far, to avoid shock a complete stripping of the quadratus lumborum from the iliac crest has not been attempted, but this step seems to be an obvious extension of the principle of the operation and we intend to adopt it in treating our next case. The "spinal-release" operation has been performed five times. In each case it has resulted in a marked improvement, best demonstrated by the roentgenograms (Figs. 14, 15, 19, and 20). We have not considered it wise to seek correction by the application of plaster-of-Paris at the time of the operation; in each case, we have waited one week until the trauma of the operation has subsided. Then, with the patient under avertin anaesthesia, a plaster spica has been applied, with maximum correction of the pelvic obliquity and of the scoliosis.

The third step of the reconstruction process is the maintenance of correction. This is unquestionably the most difficult part of the reconstruction program and we are still uncertain which procedure is most likely to be effective. Our first experience in a severe case, though disappointing, was sufficiently instructive to warrant reporting.

In this patient, I. K., the obliquity was caused by a paralysis of the right obliqui abdominis and the quadratus lumborum. After satisfactory correction of the deformity had been obtained by a series of turn-buckle plaster jackets (Hibbs method), a fusion of the spine was performed from the ninth dorsal vertebra to the fourth lumbar vertebra. The back was immobilized for three months after the operation and then a firm leather corset was applied. A year later the result was still satisfactory (see Figure 18 in previous paper [2]), but when the patient was next seen, after a lapse of three years, a severe recurrence of the obliquity had occurred. Careful analysis of the roentgenograms of the spine showed that this recurrence was due to a marked increase of the curvature above and below the fused area. The fused portion of the spine had changed only slightly since the operation.

The question naturally arises: Could the recurrence have been prevented by fusing a longer area of the spine, including the lumbosacral joints? The author was averse to a fusion of the spine to the sacrum, since, in the particular case under discussion, the patient's mode of walking seemed to demand the maximum degree of freedom of the spine and pelvis. Therefore, an attempt was made to correct the imbalance of the trunk muscles by performing the abdominal fascial plastic operation after the pelvic obliquity had been overcome a second time by our usual methods.

This operation was done a year ago. Thus far there has been no return of the obliquity, but the observation period is too short to be certain of the permanence of the result.

In four other cases, maintenance of correction by the abdominal-fascial plastic operation has been attempted. Since it is obvious that this cannot give complete replacement of the paralyzed trunk muscles, it has been supplemented by the use of a carefully fitted spinal brace of a modified Hessing type and by a rigorous system of exercises. In all four cases, some of which have been under observation over two years, there has been no recurrence. It may be possible to free these patients from the necessity of wearing the back brace by fusing the spine. The difficult problem, however, is to determine accurately the extent of the area of fusion, and, above all, whether the patient's gait will be helped or impaired by fusing the lumbosacral joints. Only further experience can answer this question.

SUMMARY

Fixation of the pelvis in an oblique position constitutes a major postparalytic deformity. There are two main etiological types of pelvic obliquity: first, that due to imbalance of the abductors and adductors of the hips: second, that due to imbalance of the trunk muscles. Both types may be recognized by muscle tests at an early stage, and frequently appropriate postural treatment will cure the condition. However, if muscle imbalance persists, operation is indicated. This is best done at an early stage before the deformity has become marked. Of the late cases of deformity, those of the first type may be completely and easily cured by the division of the contracted abductor and adductor muscles, as a rule combined with the use of a fascial transplant. The second type, however, demands a complex series of corrective procedures consisting of: (1) preoperative traction by the direct skeletal method or Roger Anderson splint; (2) operative release of the contracted spinal ligaments and muscles; and (3) maintenance of the correction by fascial transplant to replace the paralyzed obliqui abdominis and quadratus lumborum, supplemented by a suitable back brace or spinal fusion. The rules for determining accurately the extent of the area to be fused have not yet been formulated.

1. Lowman, C. L.: The Relation of the Abdominal Muscles to Paralytic Scoliosis. J. Bone and Joint Surg., XIV, 763, Oct. 1932.
2. Mayer, Leo: Fixed Paralytic Obliquity of the Pelvis. J. Bone and Joint Surg., XIII, 1, Jan. 1931.

THE RELATION OF THE PROSTATE GLAND TO ORTHOPAEDIC PROBLEMS *

BY WALLACE S. DUNCAN, M.D., CLEVELAND, OHIO

There is a surprisingly high incidence of prostatic infection in patients whose histories give no indication of infection in the genito-urinary tract. Chronic infection in the prostate and seminal vesicles is extremely common and may exist for years without producing symptoms. These organs are not always investigated, even when the patient is affected with chronic joint disease or some other remote ailment. Too infrequently is the prostate looked upon as a possible focus of infection in patients whose symptoms are indicative of the presence of general toxaemia.

A relationship between the prostate and some orthopaedic problem is found most commonly in the following conditions: (1) involvement of one or more joints, with the prostate as a focus of infection; (2) prostatitis, associated with pain in the lower back; (3) malignancy of the prostate gland, with or without metastases.

Every man with a pain in the lower back, or with arthritis in one or more joints, should be examined both by a genito-urinary surgeon and by an orthopaedic surgeon. It is almost impossible for any one other than an urologist to determine satisfactorily the condition of the prostate. Certainly, if digital examination alone in the hands of genito-urinary specialists furnishes inconclusive evidence in regard to the presence or absence of infection in the prostate gland, many cases of such infection must be overlooked when the same examination is made by those who are not specialists in this field. If the diagnosis is questionable, it may be necessary to examine the prostatic secretion repeatedly.

The Prostate as a Focus of Infection in Chronic Arthritis

The group of cases in which involvement of one or more joints is associated with a focus of infection in the prostate is of the greatest importance from an economic point of view. Of 1,252 male patients with joint symptoms, seen within the past five years at the Cleveland Clinic, all had joint symptoms sufficiently severe to cause them to seek medical advice. Of this total number, 752, or 60 per cent., were examined in the Genito-Urinary Department. Of these 752 patients, 312, or 41 per cent., had a definite prostatitis. This number represents approximately 25 per cent. of the whole group, but, if all the patients had been subjected to genito-urinary study, it is likely that the incidence of prostatic infection might have been as high as in the smaller group of patients who were referred for urological examination.

Of the patients in whom prostatitis was present, 53 per cent. were

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, New York, N. Y., January 16, 1935.

between the ages of thirty and fifty, and 88 per cent. between the ages of twenty and sixty years. A definite history of gonorrhoea was obtained in approximately 40 per cent. of these cases. The presence of syphilis was not a common finding; the blood Wassermann test showed positive reactions in twenty-six of 670 patients examined,—an incidence of 3.8 per cent.

Examinations of the teeth and throat were made in 280 of the 312 patients with prostatitis. Of this number, forty-nine, or 17 per cent., had dental infection; sixty-six, or 23 per cent., had infected tonsils; and fifty-two, or 18 per cent., had both dental and tonsillar infections. These findings are not necessarily an indication that the prostate is a more frequent focus than the tonsils or teeth, since many of these patients had been examined previously for the most obvious sources of infection. It does show, however, that the prostate is as important as any other possible source of infection, and is often a more dangerous factor in the patient's disability because less thought and consideration are given to it.

The following cases illustrate the necessity for careful study of the prostate in arthritis.

CASE 1. An unmarried man, twenty-eight years of age, had had soreness of the feet for three or four years. The right ankle had been affected first and, when no relief had been secured by local measures, the patient's tonsils were removed. His feet had then been symptom-free until eight months prior to admission, when pain, which was constantly present on walking, developed under both heels and in the anterior part of each foot. A tooth was extracted without effecting any relief.

There was considerable inflammatory reaction about both feet, with tenderness through the metatarsophalangeal joints and along the lateral borders of each os calcis. The nose, throat, and teeth displayed no evidence of infection. The patient denied having had gonorrhoea. On first examination, the prostatic secretion showed eight to ten pus cells per high-power field. In two days, the prostatic secretion was reexamined and showed from fifteen to twenty pus cells, with occasional clumps. With prostatic massage and general measures, the patient's joints became entirely symptom-free.

CASE 2. A man, aged sixty-four years, had bumped his right knee against the running board of a car seven months before admission. The knee became swollen and contained fluid. An orthopaedic surgeon had tapped it on twenty-five occasions, and twice had injected iodoform emulsion. The fluid from the knee was always sterile. About six weeks prior to admission, the patient had begun to have pain in the left knee which became swollen and contained some fluid.

The clinical examination revealed definite rigidity in the lumbar spine. The knees were swollen and hot and were in a position of flexion, with marked restriction of movement. Clinically, the condition simulated an infectious polyarthritis.

The patient's general physical condition was good. The tonsils had been removed; there was no gross evidence of infection in the teeth. The patient had had some nocturia, but there was no pain on urination and no urethral discharge. He had never had a gonorrhoeal infection. From the time of his admission, examination of the urine showed the presence of pus cells, varying from five to forty in each high-power field. Examination of the prostatic secretion showed fifty to seventy pus cells per high-power field, with considerable clumping. This condition was looked upon as a non-specific prostatitis and seminal vesiculitis.

Eventually the patient was sent to Arizona, where he was placed under a definite regimen—including heliotherapy, care of the prostate, and correction of the deformities. He made an excellent recovery and is now able to carry on normal activities, including the playing of golf.

Considering the absence of other sources of infection and the response to prostatic care, infection in the genito-urinary tract must obviously be regarded as the basis of the difficulty. This case is significant because the patient's symptoms had been present for seven months before any investigation of the urinary tract was made. It also brings out the significance of trauma and the apparent localization of what would appear to be a blood-borne infection.

Prostatitis Associated with Pain in the Lower Back

Of 238 cases in which the chief complaint was of low-back pain, foci of infection were discovered in the teeth in twenty-eight cases, in the tonsils in forty-five cases, and in both the teeth and the tonsils in thirty-four cases. The prostate was examined in only 153 cases: infection was found in eighty-three cases and no infection in seventy cases. In eighty-five cases, or 35.7 per cent. of the series, the prostate was not examined.

After reviewing many cases of backache, it is evident that certain symptoms are of considerable significance in arriving at the conclusion that the prostate may be a factor in the causation of the pain. In many cases, the onset of the discomfort is insidious. A typical history is that the patient is frequently awakened early in the morning by discomfort in the lower back, which can be relieved by changing the position in bed and also by voiding. On arising, he may or may not have moderate stiffness on bending over. As in many mechanical defects, the discomfort becomes worse when the patient is on his feet for any length of time. He frequently complains that the pain is "deep" in his lower back.

Such a man, over a period of months or even years, may have been treated by removal of tonsils and abscessed teeth, by the use of a low-back support, and by innumerable types of physiotherapy and manipulation. Later, the discovery and proper treatment of a prostatic infection have resulted in complete relief from the backache and the general symptoms, within a relatively short period of time.

The following case illustrates the importance of this point:

CASE 3. A married man, aged thirty-six years, for twenty-eight months before admission had suffered acute pain in the region of the right sacro-iliac joint while lifting. Treatment had consisted of long periods of rest in bed, manipulation of the back, and tonsillectomy, but no relief whatever had been obtained. Fusion of the sacro-iliac joint was contemplated.

Clinical examination revealed no classical signs of a right-sided sacro-iliac inflammation. No focus of infection was evident in the nose or throat, but there were twelve abscessed teeth. The prostate was boggy, and its secretion was loaded with pus cells, many of which formed clumps.

After the institution of treatment of the prostate and fitting the patient with a sacro-iliac support, much relief was obtained, although the teeth had not yet been extracted.

The necessity for repeated microscopic examination of prostatic secretion, if the diagnosis is questionable, is demonstrated by the following experience:

CASE 4. A man, aged twenty-three years, came to the Clinic with the complaint of aching in the lower back. A mechanical defect was thought to be the causative agent. Prostatic examination was made, and showed nothing of significance. However, within a week, the patient went to a dispensary, where it was found that the prostatic secretion was loaded heavily with pus. Following adequate treatment of the prostate, the pain in the back was completely relieved.

Malignancy of the Prostate with or without Metastases

Carcinoma of the prostate gland is a genito-urinary problem of interest to the orthopaedic surgeon in the differential diagnosis of pain in the lower back. In a series of 308 cases of carcinoma of the prostate seen at the Cleveland Clinic, proved bone metastases were present in eighty-five cases, and in each of these patients there was a marked preponderance of these secondary growths in the pelvis and bones of the spine.

In such cases, the pain is usually most severe at night and is relieved when the patient gets up and walks about. This is directly at variance with the symptoms related by the average patient whose back disability is attributable to some other cause. The freedom of movement in the lower back is usually found to be out of all proportion to that in patients whose symptoms are due to arthritis in the lumbar spine.

The symptoms caused by metastases to the bones from a malignant growth in the prostate are usually of long duration, as contrasted, for instance, with those from secondary growth from the breast. This is because the process in the bone is of a sclerosing type, rather than an osteoclastic type. Despite the long duration, if pain is a prominent symptom, roentgenotherapy is indicated as a palliative measure.

CONCLUSIONS

In no field of medicine or surgery has the significance of prostatic infection been brought out more strikingly than in orthopaedic surgery, and, even yet, the importance of this type of disease is insufficiently emphasized. In the presence of other sources of infection, it is impossible to be too dogmatic about the exact rôle played by prostatitis in the production of joint disturbances. However, one has only to follow from a clinical point of view the degree of improvement which some of these patients make in every respect, when adequate investigation and care of the prostate are instituted, to realize the importance and efficacy of this method of approach.

Certainly, sufficient evidence exists to show that prostatic infection, even though latent, is in many instances an important etiological agent in the production of pain in the lower back and in many cases of joint disease. Clinical experience has proved that, despite the necessity for prostatic supervision and the tendency toward recurrence of infection in the gland, symptomatic treatment of prostatitis, either alone or in conjunction with the care of other focal infections and general hygienic measures which improve the patient's general physical state, is, in the great majority of instances, accompanied by definite alleviation of the symptoms of joint disease.

THE RÔLE OF THE ILIOTIBIAL BAND AND FASCIA LATA AS A FACTOR IN THE CAUSATION OF LOW-BACK DISABILITIES AND SCIATICA*

BY FRANK R. OBER, M.D., BOSTON, MASSACHUSETTS

Pain along the course of the sciatic nerve can be one of the most disabling and distressing symptoms that man can suffer. There have been innumerable articles published on this subject describing causes and giving suggestions for relief of this condition. It is the purpose of this paper to discuss sciatic pain and its relation to certain mechanical conditions of the iliotibial band and the fascia lata, and the relation of these structures to their muscular attachments with regard to disabilities of the sacro-iliac and lumbosacral joints.

It has been shown that relief of sciatic pain often comes very quickly following sacro-iliac arthrodesis after the method of Smith-Petersen. Such early relief is not to be explained as a result of the fusion, because solid fusion does not occur so rapidly. Roberts, twelve or fourteen years ago, operated on a patient with sciatic pain to relieve what seemed to be a pathological condition of the ilium as shown by x-ray. The Smith-Petersen incision was used. No bone pathology was found and the wound was closed. The patient was relieved. Following this case, Roberts performed the same operation in sixteen other cases and obtained complete relief in all but one. Roberts did not publish his work. Heyman performed a similar operation and obtained a like result.

It would seem logical that the relief of symptoms in these cases might be due to releasing the fascial pull exerted through the fascia lata and its attachments to the gluteus maximus muscle.

ANATOMY

The iliotibial band extends from the crest of the ilium to the lateral tuberosity of the tibia, the head of the fibula, the external condyle of the femur, and the intermuscular septum between the hamstrings and the vastus lateralis. Above, the fascia lata is attached to the coccyx, sacrum, and crest of the ilium and, in part, to Poupart's ligament and the os pubis; internally, to the ramus and tuberosity of the ischium and the lower part of the great sacrosciatic ligament. Laterally, the greater part of the tendon of the gluteus maximus muscle is inserted into the fascia lata and, anterolaterally, the tensor fasciae latae is also inserted into the iliotibial band which is the tendon of the tensor. In many instances, the iliotibial band is thicker than normal above these muscular attachments and is contracted.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 6, 1935.

PATHOLOGY

The origin of the muscular attachments of the gluteus maximus and the tensor fasciae latae represents the base of a triangle whose apex is over the lateral aspect of the femur just below the trochanter. When there is a shortening of the iliotibial band and its fascial expansion, there is an abduction contracture of the femur, resulting in a tremendous leverage action on the sacro-iliac and lumbosacral joints. In most instances, the anterior portion of the fascia lata is contracted; in some, the posterior portion is contracted.

FIG. 1

F. W. Roentgenogram of hip showing calcareous deposit in fascia lata. The removal of this deposit resulted in partial relief of lame back and sciatic pain.

The sciatic nerve lies beneath the gluteus maximus where it emerges below the piriformis and any contracture of the fascia lata must exert muscular pressure on this nerve. In operations on the iliotibial band, the gluteus maximus muscle has been found to show more or less spasm.

FIG. 2

Mrs. A. T., September 20, 1934. Before operation. Lateral view of lower spine in a case of lame back with double snapping hips.

SYMPTOMS

Patients with contracted fasciae latae and iliotibial bands complain of pain in the lumbosacral or sacro-iliac regions. They may have pain in the dorsal region if there is marked lumbar lordosis and, in some instances, the pain may occur at the cervicodorsal junction.

EXAMINATION

These patients with contracted iliotibial bands exhibit the signs and symptoms which are associated with other low-back difficulties. They have limitation of motion, muscle spasm, tenderness over the lumbosacral and sacro-iliac regions and posterior to and just below the greater trochanters, sciatic scoliosis, limitation of straight-leg raising, positive Ely's sign, and functional scoliosis if the abduction contracture is unilateral.

The method of eliciting the abduction sign is as follows: The patient lies on his side, with the thigh next to the table and flexed enough to *obliterate any lumbar lordosis*. The upper leg is flexed at a right angle at the knee. The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other. The upper leg is abducted

FIG. 3

F. S., November 13, 1934. Before operation. Lateral roentgenogram showing lumbar lordosis.

widely and extended so that the thigh is in line with the body. If there is any abduction contracture, the leg will remain more or less passively abducted, depending upon the shortening of the iliotibial band. This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter.

OPERATION

Since the first article[2] on this subject was written, the line of skin incision has been changed. The incision is oblique and begins at a point a little lateral to the anterior iliac spine, extending downward and backward to a point about one inch posterior to and one inch above the greater trochanter and exposing the fascia lata. The iliotibial band and fascia lata are next incised posteriorly well over the anterior portion of the gluteus maximus muscle. The incision is now carried forward to a point just below the anterior-superior spine and includes the fascia surrounding the tensor fasciae latae. All intermuscular septa in this region are divided.

As soon as the section is completed, there is a marked separation of the cut surfaces. The fascia is further separated by blunt dissection until there is a gap of two inches. In some instances, pathological examination of the iliotibial band has shown chronic inflammation.

RESULTS

Since May 2, 1934, the author and his associates have operated upon forty-two patients. The left side was affected in fourteen cases and the right in twelve, making a total of twenty-six cases of unilateral involve-

ment. There was bilateral involvement in sixteen cases.

In a few instances, there has been relief at operation. In most cases, the relief from pain in the sciatic nerve begins on the fifth to the tenth day after operation. In other instances, where there has been a marked diminution of sciatic pain, slight twinges have persisted. There was one case of moderate recurrence ten weeks after operation, following a two-day motor ride of 1,000 miles.

Straight-leg raising increases steadily after operation. The lame back clears up in from six weeks to six or eight months, but occasionally lasts longer. The motions of the spine return to normal and the sciatic scoliosis disappears. Patients with lordotic or flat lumbosacral angles improve so that nearly a normal lumbar lordosis results. Posture improves, the increased compensatory curves decrease, and pain at the root of the neck disappears.

FIG. 4

F. S., March 12, 1935. Two months after operation. Lateral roentgenogram showing lessened lumbar lordosis.

SUMMARY

1. The simple surgical procedure described relieves sciatic pain in spines which show no bone pathology by x-ray.

2. Contracted iliotibial bands and fasciae exert pulls on the pelvic bones, resulting in bad posture.

TABLE I

RESULTS OF OPERATION

Involvement	Patients Well	Patients Improved	Patients Not Improved	Total No. of Patients
With sciatica:				
Bilateral	2	4	1*	7
Unilateral	16	3	4	23
Without sciatica:				
Bilateral	3	3	3	9
Unilateral	2	0	1	3
Total	23	10	9	42

* Operation performed too recently to judge results.

3. One more diagnostic sign has been added to our present knowledge of low-back disabilities, which should be helpful in clearing up another group of lame backs that have not responded well to other treatment.

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SACRARTHROGENETIC TELALGIA

I. A Study of Referred Pain

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This article is the first of a series * of five, the preparation of which was begun in January 1929. It is based upon the analysis of 506 examinations for low-back disability, chosen from a series of nearly 1,000 because of their completeness. Its scope is limited to a study of the pain caused by lesions of the sacro-iliac and sacrolumbar joints, and its purpose is to advance the following definition in the interest of more accurate anatomical nomenclature.

"Sacrarthrogenetic telalgia" is in no sense a diagnosis, but is a descriptive term that should be applied to the typical syndrome of pain which originates in the sacro-iliac and sacrolumbar articulations and their accessory ligaments. The referred pain (telalgia) affects the gluteal or the sacral region, or both regions, and may affect any part or all parts of the lower extremities and genito-inguinal regions except the internal crural and plantar regions. The lesions that produce this type of pain are associated with lateral spinal scoliosis. They do not cause objective neuropathological manifestations other than reflex physiopathic disorders and the atrophy of disuse.

In reviewing the literature, we have encountered five outstanding sources of confusion, the first of which is inaccurate nomenclature. "Essential", "symptomatic", "primary", or "idiopathic sciatica", "sciatic neuralgia", "sciatic pain", and "sciatic scoliosis" are terms frequently used in connection with dysfunction of the sacro-iliac and sacrolumbar joints [10, 18, 56]. By definition, sciatica is the "term commonly applied to all affections of which the chief symptom is pain in the distribution of the sciatic nerve" [58], or the name given to "a multitude of conditions which give rise to pain in the distribution of the sciatic nerve and its branches" [38]. The sciatic nerve proper is distributed to the posterior and lateral aspects of the leg and to the foot [28]. (See Figure 1.)

None of the four groups of nerves that supply the gluteal region comes from the sciatic trunk, yet our records (Table I) show that this is the region most frequently affected by sacrarthrogenetic telalgia. The posterior femoral region (sciatica), the lateral femoral region (crural neuralgia), the sacral region (sacralgia), the inguinal region (lumbo-

* The other four articles, now in preparation and to be published under the same title, deal with the following phases of the subject:
II. Sacral Mobility;
III. Alternating Scoliosis;
IV. Diagnosis;
V. Treatment.

abdominal neuralgia), and the genital region (genital neuralgia) are not included in the distribution of the sciatic nerve, but commonly are affected by sacrarthrogenetic telalgia. If one should enlarge the foregoing definitions and add "and in the distribution of the posterior femoral cutaneous (small sciatic) nerve", sciatica might be considered to include the inferior gluteal region, the posterior femoral region, and portions of the scrotum, but still it would not cover several of the areas to which sacrarthrogenetic telalgia commonly is referred. Furthermore, in any large series of cases, an affection of the trunk of a nerve should involve all portions of that nerve's distribution, and, although the plantar type of sciatica is said to be intensely painful [71], none of our case records shows telalgia affecting the sole of the foot. Finally, Oppenheim has said: "Sciatica generally holds to the course of one nerve so that the patient can *trace the whole pain tract with his finger*", but, despite our every effort to obtain accurate localization of pain in each case, our patients' answers indicate that areas of telalgia are likely to be wide-spread and not sharply delimited. If sacrarthrogenetic telalgia regularly involves areas beyond the boundaries of the sciatic distribution, consistently shuns certain sciatic territory, and is difficult to localize, then the terms "sciatica" and "sacrarthrogenetic telalgia" are not synonymous and should be divorced.

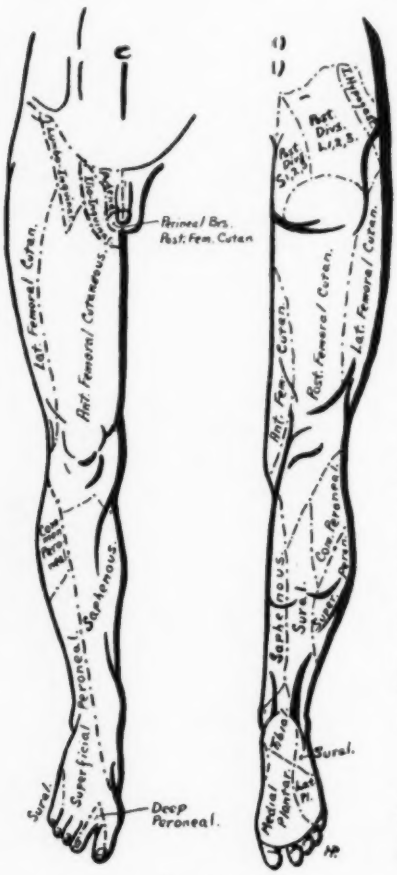

FIG. 1

Distribution of the cutaneous nerves in the buttock and lower extremity. [28]

Inaccurate nomenclature inevitably has led to inaccurate conceptions of the origin of sacrarthrogenetic telalgia. Thus the second great source of confusion is the direct result of the first and is found in the attempts of many authors to explain the referred pain on the basis of direct pressure *, or other irritating stimuli applied to the sciatic nerve, the sacral plexus, or the individual nerve roots from which they are formed.

* Among those who took this view are: Baer, Bauman, Chapman, Cox, Dunlop, Freiberg, Freiberg and Vinke, Goldthwait and Osgood, Haglund, Jackson, McClure, Meisenbach, Nutter, Peckham, Pitfield, Ridlon and Berkheiser, Ryerson, Sachs, Winsor, Yeoman, and Young. (See Bibliography.)

It seems reasonable to us to suppose that spasm of the piriformis and other muscles occasionally may cause pressure upon the sciatic trunk and so produce the syndrome of irritation or compression of a peripheral nerve *, although Schüdel has stated that the piriformis, when contracted, bridges and protects the sciatic nerve. We do not doubt that inflammation†, extending from the sacro-iliac joints and other structures that lie in close proximity to the lumbosacral cord and sacral plexus, may cause similar disturbances. We have seen a number of cases of radiculitis and funiculitis apparently caused by spondylitic (Danforth and Wilson, Verrall, and Williams), spondylo-arthritic (Craig and Ghormley, Goldthwait, Putti, and Rogers), or spondylolisthetic narrowing (Johnson, Mitchell, Smith, Von Lackum, and Williams and Yglesias) of the intervertebral foramina. But, if we exclude the occasional case of reflex physiopathy [2], we cannot agree with the assumption that pressure upon a nerve root, plexus, or trunk may cause pain in areas not supplied by those structures. The regions most frequently affected by sacrarthrogenetic telalgia (Table I) are supplied by peripheral nerves derived from both the anterior and the posterior divisions of every spinal nerve from the first lumbar segment to the third sacral segment. To account for the referred pain on the basis of direct pressure, one must predicate either an ascending or a reflex irritation, a widespread lesion, or a lesion at the level of the first lumbar segment [45]. It seems incredible to us that lesions of any one of these types regularly should fail to involve those portions of the third and fourth lumbar nerves that supply the internal crural region, yet none of our patients has complained of telalgia in the distribution of the

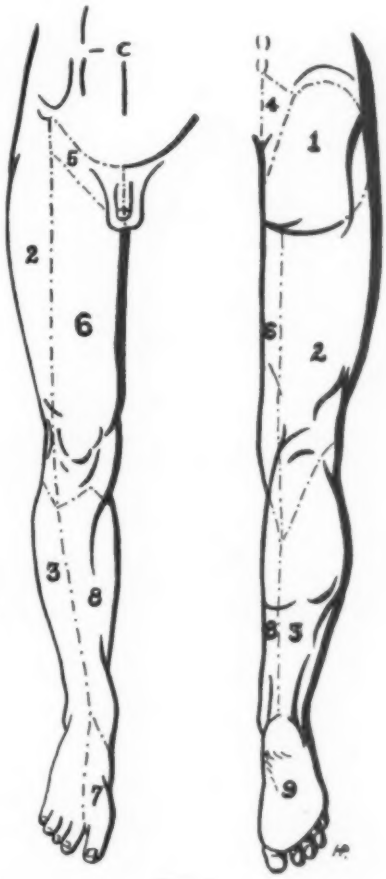

FIG. 2

Suggested division of the buttock and lower extremity into regions for purposes of history-taking in sacrarthrogenetic telalgia.

* This theory was supported by such authors as: Babinski, Barshinger, Bradford and Brackett, Cofield, Ehret, Freiberg and Vinke, Guse, Heald, Kleinberg, Roberts, and Yeoman.

† Among those who attributed the cause to inflammation are: Blencke, Chapman, Cyriax, Frauenthal and Finkelstein, Grossman and Keschner, Key, Maclean, Miltner and Lowendorf, Plate, Rogers, Ryerson, Thornton, Williams, and Yeoman.

TABLE I

CLASSIFICATION OF SACRARTHROGENETIC TELALGIA BY ANALYSIS OF 404 RECORDS OF TELALGIA FOUND IN

Region	Area of Telalgia	Cutaneous Innervation of Area
1.	Buttock (and Intergluteal Triangle)	Posterior divisions of lumbar I, II, III. Posterior divisions of sacral I, II, III. Iliohypogastric from lumbar I. Gluteal branches of posterior femoral cutaneous from sacral I, II, III.
2.	Thigh and/or Knee (Posterior and/or Lateral)	Iliohypogastric from lumbar I. Lateral femoral cutaneous from lumbar II, III. Posterior femoral cutaneous from sacral I, II, III.
3.	Leg (Posterior and/or Lateral) and/or Dorsolateral Foot and/or Last Four Toes	Common peroneal from lumbar IV, V; sacral I, II. Superficial peroneal from lumbar IV, V; sacral I. Sural from sacral I, II.
4.	Intergluteal Triangle Only	Posterior divisions of lumbar IV, V. Posterior divisions of sacral I, II, III.
5.	Groin and/or Genitalia	Ilio-inguinal from lumbar I. Lumbo-inguinal from lumbar I, II. Perineal branches of posterior femoral cutaneous from sacral I, II, III. Pudendal from sacral II, III, IV.
6.	Thigh and/or Knee (Anterior and/or Medial)	Anterior femoral cutaneous from lumbar II, III.
7.	Foot (Dorsal and/or Medial) and/or Great Toe	Superficial peroneal from lumbar IV, V; sacral I. Deep peroneal from lumbar IV, V.
8.	Leg (Anterior and/or Medial)	Saphenous from lumbar III, IV.
9.	Foot (Sole)	Plantar: medial from lumbar IV, V; lateral from sacral I, II. Tibial from sacral I, II.

* Telalgia in the sacral region (Region 4) is listed separately only when no other region is involved, because of the difficulty that we experienced in distinguishing it from gluteal telalgia. All cases in which there were changes in reflexes, or sensation, or tenderness of the trunks of peripheral nerves have been rigidly excluded.

TABLE I—*Continued*

REGIONS,* INNERVATION OF THESE REGIONS, AND 506 EXAMINATIONS FOR LOW-BACK DISABILITY

Derived from Spinal Nerves		Dermatomes		Telalgia		
				Cases **		Pain †
Anterior Divisions	Posterior Divisions	Anterior	Posterior	*No.*	*Per Cent.*	*Per Cent.*
Lumbar I Sacral I, II, III	Lumbar I, II, III Sacral I, II, III	Lumbar I Sacral I, II, III	Lumbar I, II, III Sacral I, II, III	357	88.0	43.0
Lumbar I, II, III Sacral I, II, III		Lumbar I, II, III Sacral I, II, III		218	54.0	26.0
Lumbar IV, V Sacral I, II		Lumbar V Sacral I, II		114	28.0	14.0
	Lumbar IV, V Sacral I, II, III		Lumbar IV, V Sacral I, II, III	(68)	(17.0)	(8.0)
Lumbar I, II Sacral I, II, III, IV		Lumbar I Sacral III		52	13.0	6.0
Lumbar II, III		Lumbar II, III		16	4.0	2.0
Lumbar IV, V Sacral I		Lumbar V (Sacral I)		12	3.0	1.0
Lumbar III, IV		Lumbar IV		0	0	0
Lumbar IV, V Sacral I, II		(Lumbar V) Sacral I		0	0	0

** In these 404 cases, 837 regions were involved, an average of 2.1 regions per case.

† This heading refers to the incidence of pain in any given region as compared with the total incidence of pain in all regions.

saphenous nerve. Finally, motor and sensory changes regularly are associated with compression of nerves [80], but motor and sensory changes are conspicuously absent in telalgia. Sensory and trophic changes are to be expected in cases of irritation of nerves [80], but the vasomotor and sudomotor disturbances which frequently are noted in telalgia are not associated with objective sensory changes, and, when atrophy is present, the electrical reactions are normal. Therefore, these changes belong to the functional groups of reflex physiopathic disturbances and phenomena of disuse. *Sacrarthrogenetic telalgia is not the result of compression or irritation of the trunks of peripheral nerves.*

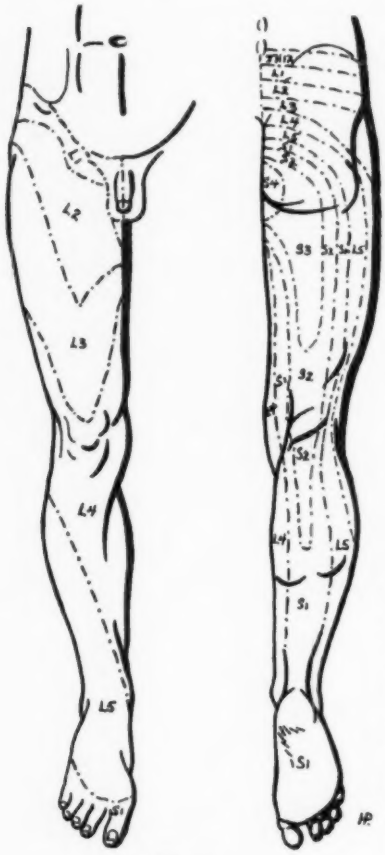

FIG. 3

Dermatomes of the lower extremity, as represented by those who follow Head's teachings.[38]

The evidence adduced by several authors to explain sacrarthrogenetic telalgia on a segmental basis has been summarized by Miltner, and will not be repeated here. Head wrote: "Where a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility, the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied". The external surface of the body is, of course, the "part of higher sensibility", but a third source of confusion appears when we attempt to delineate the segmental spinal sensory areas, or dermatomes, in the lower extremities. By the wide divergence of opinion expressed therein, the literature reflects the present impossibility of defining these dermatomic areas with sufficient accuracy to allow one diagram to fit all cases. Most of the diagrams can be fitted into one of two groups: those which follow Head's teachings (Fig. 3), and those which follow Dejerine's (Fig. 4). To avoid controversy, we have classified our records of telalgia by regions (Fig. 2). This is convenient because it groups certain contiguous dermatomes, the exact location of which has been a source of confusing argument. For example: those authors who would show that pressure upon the emerging fifth lumbar funiculus is responsible for pain referred to the lateral aspect of the leg [18] have reproduced the diagrams of several authorities to prove that

this is the normal location of the fifth lumbar anterior (ventral) dermatome (Fig. 3). Those who ascribe such pain to lesions of the sacro-iliac joint [77] have found other authorities to prove that the lateral crural region is a part of the first and second sacral anterior dermatomes (Fig. 4).

In the inquiry at hand, the upper sacral joints represent the "part of lower sensibility", but the determination of their innervation is the fourth and greatest source of confusion that we have encountered. Many anatomists ignore the problem entirely.* Few of them illustrate their dissections. Those who describe the innervation of these joints usually group each joint and its far-flung ligaments as a unit, and, so far as we have been able to determine, only Rüdinger and Smith-Petersen have reported dissections of the innervation of each individual articulation and ligament. The sacro-iliac joint usually is said to be supplied thus:

1. Anteriorly, by direct branches of the lumbosacral cord which is derived from the anterior divisions of the fourth and fifth lumbar nerves;**

2. Inferiorly, by branches of the superior gluteal nerve which is derived from the anterior divisions of the fourth and fifth lumbar nerves and the first sacral nerves;†

3. Posteriorly, by direct branches of the posterior primary divisions of the first and second sacral nerves;

4. By branches of the obturator nerve which is derived from the anterior divisions of the second, third, and fourth lumbar nerves;‡

5. By branches of the pelvic portion of the sympathetic gangliated cord.

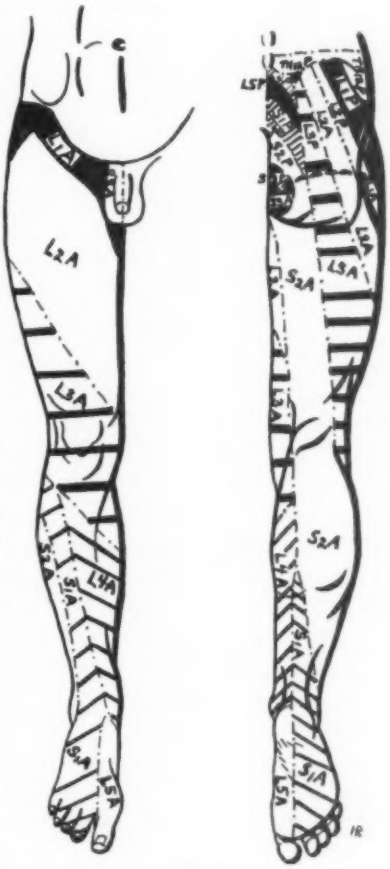

FIG. 4

Dermatomes of the lower extremity, as represented by those who follow Dejerine's teachings. [83]

* In such standard anatomical texts as Cunningham, Gray, Piersol, and Spalteholz, we could find no description of the innervation of the upper sacral joints.

** In a monograph in which he described and illustrated his careful dissections of the innervation of every joint in the body, Rüdinger stated that he could find no nerves to the sacro-iliac joint on its anterior aspect, but only branches of the posterior divisions of the sacral nerves on the posterior aspect.

† Quain and Wilson illustrated a small branch of the superior gluteal nerve running to the posterior-inferior iliac spine. Those authors who include this innervation usually state that these branches accompany the nutrient vessels into the ilium.

‡ Hilton seems to have been the first to describe this innervation; Von Bardeleben followed him; Testut quoted Hilton, but did not verify this source of supply; Morris and later authorities entirely omitted the obturator nerve

The sacrolumbar joint usually is said to be supplied thus:

1. By direct branches of the fourth and fifth lumbar nerves; *
2. By branches of the lumbar portion of the sympathetic gangliated cord.

These descriptions led Smith-Petersen and others (Cowan, Harris, and Pitfield) to conclude that pain from the sacrolumbar joint should be referred only to the last two lumbar dermatomes (Fig. 4). They concluded also that pain from the sacro-iliac joint should be referred to the last two lumbar and first two sacral dermatomes, with additional radiation along the courses of the superior gluteal and obturator nerves. Head's rule indicates that painful stimuli from the upper sacral joints should travel centrally in the anterior divisions of the last four lumbar nerves and first sacral nerve and in the posterior divisions of the first two sacral nerves. Thus, the referred pain should affect the last four lumbar anterior dermatomes and first sacral anterior dermatome, as well as the first two sacral posterior dermatomes **. However, sacrarthrogenetic telalgia regularly fails to involve the fourth lumbar anterior dermatome (Table I) and only rarely involves the second and third lumbar anterior dermatomes. To explain genito-inguinal telalgia, Smith-Petersen concluded that, while some of the painful stimuli are referred to dermatomes, others are referred as a neuralgia to the course of the trunk of the obturator nerve. Head's rule offers no explanation for telalgia in the first lumbar anterior dermatome and third sacral anterior dermatome. We have not found any author who explained the production of widely different patterns of pain, within a few minutes or hours, by the same lesion in the same patient, or who investigated the reasons why sacrarthrogenetic telalgia affects certain portions of its usual distribution more frequently than others. Therefore, we decided that a more exact determination of the innervation of the individual elements of the upper sacral joints and their ligaments was necessary.

Our dissections of four cadavera led us to agree with Rüdinger's findings. (See Figure 5.) The innervation of the capsule of each sacrolumbar articular facet is derived from the posterior division of the fifth lumbar nerve which passes close to the articulation on its way to the multifidus muscle. The lateral branch of the fifth lumbar posterior division communicates with the corresponding element of the fourth lumbar nerve and with the posterior sacral plexus. This plexus is formed by the lateral branches of the posterior divisions of the first three sacral nerves and sends a communicating loop to the posterior division of the fourth sacral nerve. The plexus lies deeply imbedded in the dense sacro-iliac and sacro-ischial ligaments and is separated from the sacrum by a thin layer of ligaments

* Almost all authorities agree on this innervation, but, like Mitchell, they neither state the exact supply of the articular facet as distinct from the joint as a whole nor differentiate between the anterior and posterior divisions of these nerves.

** The posterior (dorsal) dermatomes are well described by Tilney and Riley, but are too narrow to be of much use in differential diagnosis; indeed confusion may arise from the fact that the posterior margin of the sacro-iliac joint lies directly in front of the fifth lumbar posterior dermatome. The fourth and fifth lumbar dermatomes and the first sacral posterior dermatome are not continuous with the corresponding anterior dermatomes in the lower extremity. There are no posterior dermatomes in the lower extremity.

TABLE II

A MORE DETAILED ANALYSIS OF THE 404 CASES RECORDED IN TABLE I

Region	Unilateral Pain			Bilateral Pain			Pain All Types			Expectancy †	
	Cases		Pain*	Cases		Pain*	Cases		Pain*	Impulses	Pain
	No.	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*
1.	201	84.0	41.0	156	94.0	45.0	357	88.0	43.0	84	43.0
2.	154	64.0	31.0	64	39.0	19.0	218	54.0	26.0	38	20.0
3.	78	33.0	16.0	36	22.0	10.0	114	28.0	14.0	30	15.0
4.	(16)	(7.0)	(3.0)	(52)	(32.0)	(15.0)	(68)	(17.0)	(8.0)	(10)	(5.0)
5.	36	15.0	7.0	16	10.0	5.0	52	13.0	6.0	6	3.0
6.	4	2.0	1.0	12	7.0	3.0	16	4.0	2.0	8	4.0
7.	4	2.0	1.0	8	5.0	2.0	12	3.0	1.0	6	3.0
8.	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	12	6.0
Total	493 (239 patients)	207.0	100.0	344 (165 patients)	209.0	99.0	837 (404 patients)	207.0	100.0	194	99.0

* This heading refers to the incidence of pain in any given region as compared with the total incidence of pain in all regions.

† See footnote to page 124 for method of calculating the expectancy of referred pain for each region.

and periosteum. It distributes branches from the fifth lumbar nerve and from the first two sacral nerves to the interosseous sacro-iliac ligaments and the sacro-iliac joint.

Thus painful stimuli arising within the sacrolumbar zygapophysial articulations must travel centrally in the posterior divisions of the fourth and fifth lumbar nerves. Painful stimuli arising within the sacro-iliac articulation must travel centrally in the posterior divisions of the fifth lumbar nerve and first and second sacral nerves. Therefore, each articulation has a "close central connection" only with the posterior dermatomes (Fig. 4). *Telalgia in the posterior dermatomes of the sacral region is caused by intra-articular lesions of the upper sacral joints and frequently persists after radiation to the anterior dermatomes in the lower extremities has ceased.***

** The same mechanism that produces pain in these posterior dermatomes conceivably might be responsible, by an intrasegmental transmission of stimuli, for pain referred to the fifth lumbar and first and second sacral anterior dermatomes in the lower extremity. Still we have not explained the telalgia in the major portion of the buttock, in the lateral femoral region, in the anterior femoral region, or in the groin. Therefore, we must search

The dense fibrous tissue, generically known as tendon, by which the contractile substance of each muscle is attached to the skeleton or other structures, phylogenetically represents a portion of the original muscle converted into connective tissue [61] and is innervated by twigs of the nerves that ramify within the substance of that muscle [9]. By such myomeric degeneration, the sacrotuberous and long posterior sacro-iliac ligaments were formed [53] as direct continuations of the tendinous origin of the semitendinosus and the long head of the biceps femoris muscles. The common aponeurotic tendons of the sacrospinalis and gluteus maximus muscles, which blend with the posterior sacro-iliac and sacrotuberous ligaments, similarly represent portions of those muscles which have undergone tendinous degeneration. The anterior sacro-iliac and lumbosacral ligaments are direct continuations of the fibers of origin of the iliacus muscle from the transverse processes of the last lumbar and the first three sacral vertebrae. They are analogous to the intertransverse ligaments [53] and tendinous origins of the psoas and quadratus lumborum muscles from the transverse processes of the lumbar vertebrae. The accessory ligaments of the upper sacral joints are not exceptions to the general rules governing the innervation of similar structures throughout the body, but actually receive nerve fibers from the muscles to which they afford attachment. We have been able to trace in autopsy material, by histological sections *, the course of nerve fibers that pass from the muscles to end in these ligaments. Such nerve fibers are scarce, as they are elsewhere in tendinous tissue, but they undeniably are present, and their very scarcity adds to the qualifications of these ligaments as "parts of low sensibility".

The iliolumbar ligaments, which act as a hammock for the fifth lumbar vertebra [46], afford partial origin to the sacrospinalis and multifidus muscles. Thus they have access to muscular twigs from the posterior divisions of all the five lumbar and the first three sacral nerves (Table III). Painful stimuli that travel centrally in these nerves may appear as telalgia in the corresponding posterior dermatomes (Fig. 4). Each iliolumbar ligament also receives twigs of nerves from the quadratus lumborum and iliacus muscles, thus establishing a direct central connection with the first, second, and third lumbar anterior dermatomes.

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for a direct connection between the ligaments [8] of the upper sacral joints and the anterior divisions of the lumbar and sacral nerves in order to establish a "close central connection" with the anterior dermatomes. A clue to this connection is found in Partridge's restatement of Hilton's law: "No joint is moved by any muscle whose nerve does not also supply a twig to that joint, and all the nerves which supply a moveable joint are branches of the nerves which supply the muscles moving the joint, and their distribution is on that surface of the joint which is controlled by those muscles." If the sacro-iliac joint obeyed this law, its ligaments should receive nerves from every muscle that attaches to the pelvis or sacrum, and its articular nerves presumably would be so numerous or so large that they would be dissected and described by every anatomist. Apparently the term "movable joint" was inserted into the law in an attempt to exclude the sacro-iliac joints, and Partridge did not state any corollary which covers them.

* The gross anatomical research presented in this paper was done by one of us in the Department of Anatomy of the University of California; the histological work, in the Department of Pathology of the University of California Medical School. The illustration of the gross dissections was made by a staff artist in the Art Department of the University of California Medical School.

FIG. 5

The posterior sacro-iliac and sacro-ischial ligaments (left). The posterior sacral plexus and the innervation of the sacrolumbar and sacro-iliac articulations (right).

The sacrolumbar and anterior sacro-iliac ligaments give origin to only one muscle,—the iliacus. Through the anterior divisions of the second and third lumbar nerves these ligaments have a direct central connection with the corresponding anterior dermatomes.

The posterior sacro-iliac and sacro-ischial ligaments have access to four different types of innervation:

1. Direct branches from the posterior sacral plexus (fifth lumbar posterior division to third sacral posterior division), which are given off by the common cord as it descends to pierce or to curve around the inferior margin of the gluteus maximus muscle (Fig. 5).

2. Twigs from the origins of the sacrospinalis and multifidus muscles (first lumbar posterior division to third sacral posterior division).

3. Probably some small direct branches from the anterior division of the fourth sacral nerve, when it pierces the sacrotuberous ligament.

4. Twigs from the origins of the gluteus maximus, piriformis, biceps femoris (long head), and semitendinosus muscles (fifth lumbar anterior division to third sacral anterior division).

Thus the posterior sacro-iliac and sacro-ischial ligaments have a close central connection with the first three sacral posterior dermatomes and all of the five lumbar posterior dermatomes, with the fifth lumbar an-

TABLE III

THE INNERVATION OF THE SACRO-ILIAC, ILIOLUMBAR, AND SACRO-ISCHIAL LIGAMENTS[25]

Ligament	Original Muscle	Ligamentous Surface	Local Innervation	Spinal Nerve	
				Posterior Division	Anterior Division
Iliolumbar	Iliacus	Superior Anterior	Femoral		Lumbar II, III
	Quadratus lumborum	Superior	Direct		Lumbar I
	Sacrospinalis	Posterior	Direct	Lumbar I to V	
	Multifidus	Posterior	Direct	Lumbar III, IV, V Sacral I, II, III	
Anterior Sacro-Iliac Anterior Sacrolumbar	Iliacus	Anterior	Femoral		Lumbar II, III
Short Posterior Sacro-Iliac			Posterior sacral plexus	Lumbar V Sacral I, II	
	Gluteus maximus	Posterior	Inferior gluteal		Lumbar V Sacral I, II
	Sacrospinalis	Posterior	Direct	Lumbar I to V	
Long Posterior Sacro-Iliac	Multifidus	Posterior	Direct	Lumbar III, IV, V Sacral I, II, III	
Sacrospinous			Posterior sacral plexus	Sacral I, II, III	
	Piriformis[25]	Anterior	Direct		Sacral I, II
Sacrotuberous			Posterior sacral plexus	Sacral I, II, III	
	Piriformis	Anterior	Direct		Sacral I, II
	Gluteus maximus	Posterior and lateral	Inferior gluteal		Lumbar V; Sacral I, II
	Sacrospinalis	Posterior and medial	Direct	Lumbar I to V	
	Biceps femoris (long head)	Inferior end	Sciatic (tibial portion)		Sacral I, II, III
	Semitendinosus	Inferior end	Sciatic (tibial portion)		Lumbar V; Sacral I, II, III
			Anterior sacral plexus		Sacral IV

TABLE IV

ANALYSIS OF 330 CASES IN WHICH TENDERNESS WAS FOUND IN 506 EXAMINATIONS FOR LOW-BACK DISABILITY

Point of Tenderness	Cases *		Tenderness
	No.	*Per Cent.*	*Per Cent.*
Lumbosacro-iliac angle	252	76.0	28.0
Posterior iliac interspinous notch	249	75.0	27.5
Lesser sacrosciatic notch	184	56.0	20.0
Sacrotuberous ligament (free edge)	118	36.0	13.0
Sacrolumbar interspinous ligament	42	13.0	5.0
Sacral interspinous ligaments	31	9.0	3.0
Sciatic trunk in thigh	17	5.0	2.0
Iliolumbar ligament at iliac crest	12	4.0	1.0

* In these 330 cases, there were 905 tender points, an average of 2.7 tender points per case.

terior dermatome and the first three sacral anterior dermatomes, and probably with the fourth sacral anterior dermatome.

To recapitulate: *Pain may be referred from the sacrolumbar zygapophysial articulation to the fourth and fifth lumbar posterior dermatomes; from the sacro-iliac articulation to the fifth lumbar and first and second sacral posterior dermatomes; from the iliolumbar ligament to all of the five lumbar and the first three sacral posterior dermatomes, as well as to the first three lumbar anterior dermatomes; from the sacrolumbar and anterior sacro-iliac ligaments to the second and third lumbar anterior dermatomes; from the posterior sacro-iliac and sacro-ischial ligaments to all of the five lumbar and the first three sacral posterior dermatomes, as well as to the fifth lumbar and the first three (or four) sacral anterior dermatomes.*

It should be noted that none of these structures has a close central connection with the fourth lumbar anterior dermatome, and there seems to be no controversy over the location of this dermatome in the anterior crural region (Figs. 3 and 4). None of our patients has complained of telalgia in this region.

Only the posterior sacro-iliac and sacro-ischial ligaments have close central connections with the dermatomes in the lateral crural region. This finding tends to emasculate the arguments concerning the location of the fifth lumbar anterior dermatome and the first and second sacral anterior dermatomes.

Less easy to explain is the fact that none of our patients has com-

Lumbar V; Sacral I, II, III
Sacral IV
Sciatic (tibial portion)
Anterior sacral plexus
Inferior end
Semitendinosus

plained of pain referred to the sole of the foot. A majority of the authorities represent the plantar region as the first sacral anterior dermatome, which has a close central connection with the posterior pelvic ligaments. Our only explanation of this phenomenon is that the thickened skin of the sole of the foot may not qualify as a "part of much greater sensibility" to pain than the pelvic ligaments.*

Many allegedly tender anatomical structures have been described in cases of sacrarthrogenetic telalgia. Because we have found in these descriptions a fifth source of confusion, we have limited our palpation and records of tenderness to eight easily recognizable landmarks (Table IV) which include the accessible portions of all the posterior ligaments of the upper sacral joints. The lumbosacro-iliac angle and the posterior iliac interspinous notch show the two highest percentages of tenderness in this group, and the latter presents the obvious diagnostic advantage of containing fewer anatomical structures to confuse the examiner.** Furthermore, it appears that the free edge of the sacrotuberous ligament above and medial to the ischial tuberosity was found to be tender in more than one-third of our cases. Because of the relative isolation of the ligament at this point, the possibility of confusing such tenderness with that of other anatomical structures is minimal. We have found, as have others [13, 37], that pressure upon some one of these tender spots occasionally produces or aggravates the telalgia of which the subject complains. When pressure upon the free edge of the sacrotuberous ligament causes this phenomenon, as it has done in several of our cases, strong presumptive evidence is produced to show that the ligaments are the source of the referred pain.

CASE REPORTS

CASE 1. M. M., a white girl, nineteen years of age, complained of sacral backache of nineteen days' duration. The pain was vague at onset, non-radiating, constant, dull, and aching in character. It was somewhat relieved by lying on the right side. It was

* It is interesting to note that, if our theory is carried to its logical conclusion, it should be possible to anticipate the frequency with which sacrarthrogenetic telalgia will affect any given region. This we have done, and it appears that the expectancy of referred pain for each region shows more than a casual relationship to the actual experience (Table II). The expectancy was calculated as follows: We assumed that a single painful stimulus could be applied with equal intensity to each individual part of the upper sacral joints and their ligaments (Table III). The number of impulses so generated in each primary division of the spinal nerves was tabulated and reduced to a percentage of the total for all regions (except Region 4). This value was considered to be the expectancy for the corresponding dermatomes, and the expectancy for each region was computed as the sum of the values of its component dermatomes. Thus, without attacking the complex problem of the intrasegmental and intersegmental spread of stimuli through intercalated cells, we arrived at the figures shown in the last column of Table II, with one exception. The clinical figures for Region 4 represent those patients who had no pain except that in the intergluteal triangle, and, since the only structures which can produce telalgia in the sacral region without causing other radiation are the sacrolumbar and sacro-iliac articulations, the expectancy for this region alone is the sum of the impulses from the joints proper, reduced to a percentage of the total value of all other regions. The greatest discrepancy between experience and expectancy is 6 per cent., and it would seem that a larger experience might make the comparison even more striking.

** The structures affected by pressure applied over the interspinous notch are: the skin and subcutaneous tissue, the gluteus maximus muscle, the long posterior sacro-iliac ligament, and those portions of the short posterior sacro-iliac and sacrotuberous ligaments that attach to the posterior-inferior iliac spine.

aggravated by all motions of the trunk or legs, by coughing or sneezing, by riding in automobiles, and by missteps.

Family History: The mother had died of pulmonary tuberculosis when the patient was three years old.

Past History: The patient had spent two brief periods in sanatoria (one at the age of thirteen and another at the age of sixteen) for a tuberculous lesion of the left apex, which was said to have been arrested.

Physical Examination: The mouth temperature was 99 degrees. The pulse was 72; the respirations, 20 per minute. The patient was a well-developed and well-nourished girl of the slender anatomical type, who stood in fair posture with the right knee semiflexed. With both knees straight, she showed a decrease in the normal lumbar lordosis, a total left lateral scoliosis, with a list of the trunk to the right, and a rotation of the left shoulder and left buttock backward behind the plane of the heels. She carried the right shoulder and right buttock lower than the left. There was marked spasm of the right sacrospinalis muscle. Palpation revealed almost no tenderness anywhere. Percussion of the sacrum and compression of the iliac crests aggravated the sacral backache. All motions of the spine and right hip were guarded. Straight-leg raising on the left was 80 degrees; on the right, 50 degrees. Prone knee flexion[63] lacked three inches on the left and twelve inches on the right. The lower extremities were equal in length and circumference. The planes of the anterior-superior and posterior-superior spines of each ilium were symmetrical and were inclined forward 10 degrees on either side. There was dullness with distant respiratory sounds and vocal resonance and diminished fremitus at the left apex, but no râles.

Rectal Examination: Some tenderness was found high up toward the sacro-iliac joint on the right.

Roentgenographic Examination: Scarring and pleural thickening were seen at the left apex. There was some faint cloudiness of the right sacro-iliac joint.

Laboratory Examination: A Wassermann test was negative. An intradermal tuberculin test (Atsatt) was positive up to and including a dilution of 1:10,000. The blood showed:

Red blood cells—4,200,000
White blood cells—9,800
Polymorphonuclears—64 per cent.
Lymphocytes—30 per cent.
Mononuclears—4 per cent.
Eosinophiles—2 per cent.

Diagnosis: Tuberculous arthritis of the right sacro-iliac joint. Healed pulmonary tuberculosis of the left upper lobe.

Advice: Arthrodesis of the right sacro-iliac joint. (This was refused by the father.)

Course: Immediate treatment included hospitalization, a bed on the roof, heliotherapy, and the application of a plaster spica from the toes on the right and the knee on the left to the nipple line. Some relief from pain was obtained by the application of local heat to the right sacro-iliac region through a window in the cast. Ten days after admission, the patient developed telalgia in the right anterolateral femoral region, which steadily increased in severity for three days. On the third day, the patient also complained of telalgia in the right buttock, posterior femoral region, and calf. Shortly thereafter all pain disappeared rapidly and was gone within an hour. A roentgenogram, taken two weeks after entry (the day after the pain had disappeared), showed an early destructive lesion in the anterior margin of the right sacro-iliac joint. The patient rapidly developed a large abscess in the right iliac fossa, which eventually pointed in the groin and was aspirated three times. Aerobic and anaerobic cultures of the pus from this abscess showed no growth, but a guinea-pig, inoculated with one of these specimens, developed typical tuberculous lesions. Suddenly, ninety-six days after admission, the patient died. The apparent cause of death was pulmonary embolism, but post-mortem examination was denied us by the father.

This case seems to show that an early tuberculous lesion in the sacro-iliac joint caused pain referred only to the sacral region. The pressure of the pus within the joint was transmitted at first to the weak anterior ligaments and caused telalgia in the second and third lumbar anterior dermatomes. When the pressure within the joint became extreme, it was transmitted to the strong posterior ligaments and caused a transient radiation to the first and second sacral anterior dermatomes. When the anterior capsule finally was ruptured, relief from telalgia was prompt, and the pain did not recur during the rest of the course of the disease.*

CASE 2.** G. McN., a white boy, aged ten years and five months, complained of pain in the right buttock, of eight days' duration. The onset of pain was acute, with fever. The pain was non-radiating; it had become steadily more severe since onset; it was aggravated by turning in bed, by lying prone or on the right side; and it was relieved by nothing. Three days after the onset, numerous minute red spots appeared on the patient's chest and abdomen, but he did not complain of tender fingers or toes.

Physical Examination: The patient was a well-developed and well-nourished boy whose general physical examination was negative, except as noted. The mouth temperature was 100.2 degrees. The pulse was 100; the respirations, 22 per minute. The cheeks were flushed, and the skin was hot. There were petechial spots on the chest and abdomen. The boy could not stand without support. He bore his entire weight upon the left leg, with the right knee bent, and showed a marked list of the trunk to the right. All the lumbar muscles were in extreme spasm, and there was an accentuation of the normal lumbar lordosis. Tenderness was maximal over the upper two-thirds of the right sacro-iliac joint. Supine hip-and-knee flexion was performed normally. Straight-leg raising was 45 degrees on the left, 35 degrees on the right. Hyperextension of the right hip was not possible. Compression of the iliac crests caused immediate excruciating pain in the right sacro-iliac joint and, occasionally, in the lower portion of the right buttock where there was no direct tenderness. The lower extremities were equal in length and circumference. All of the deep reflexes were diminished in the right lower extremity and were slightly hyperactive in the left where there was a tendency toward ankle clonus.

Rectal Examination: There was tenderness high up toward the sacro-iliac joint on the right.

Roentgenographic Examination: There was a slight cloudiness of the right sacro-iliac joint space.

Laboratory Examination: A Wassermann test was negative, as was the Atsatt tuberculin test. The blood showed:

Red blood cells—4,600,000
Hemoglobin—90 per cent.
White blood cells—16,000
Polymorphonuclears—79 per cent.

Diagnosis: Septicaemia with acute (suppurative?) arthritis of the right sacro-iliac joint.

Course: On the day after admission, the patient's temperature rose to 104 degrees. On the second day, there was a marked amelioration of symptoms, and the white blood count increased to 17,000 with a differential count of 90 per cent. polymorphonuclear leukocytes. It was decided that the focus had drained spontaneously, and that surgery should be delayed until a localized abscess had developed in the soft tissues. For two

* Heath reported three cases of "sacro-iliac disease" (tuberculosis) in each of which pain was relieved by aspiration of an abscess.

** For permission to use this case report, the authors are indebted to Dr. Robert B. Osgood, on whose Service in the Children's Hospital, Boston, Massachusetts, this patient was treated.

weeks the patient continued to improve. A subsequent roentgenogram showed a destructive lesion in the right sacro-iliac joint, with widening of the joint and some proliferation of new bone. On the fifteenth day after admission, there was a recurrence of pain in the right buttock, an elevation of the temperature to 102.8 degrees, and the white blood count rose from 10,000 to 18,000. Two days later Dr. Ober explored the right buttock. Considerable oedema of the soft tissues was found, but no abscess. The iliac bone opposite the lower half of the sacro-iliac joint was soft and necrotic. When a triangular section of this bone had been removed, it was seen that the joint cartilage on its deep surface was necrotic and flaking away. There was also some involvement of the contiguous sacral cartilage, but there was no pus. Cultures of the excised bone showed a profuse and uncontaminated growth of staphylococcus albus. The wound was drained. Convalescence was uncomplicated, and the child was sent to the Wellesley Convalescent Home one month after operation. The case was followed for fifteen months. No recurrence of symptoms was noted.

Plagemann reported a case of acute suppurative osteo-arthritis involving the right sacro-iliac joint in a boy of nineteen years. This case is very similar to ours except that, in addition to the pain in the right gluteal region, there was also pain radiating to the right thigh (we do not know the exact region). A focus of pus and granulation tissue was removed surgically from the sacral surface of the right sacro-iliac joint. In our case, an almost identical lesion which did not go on to pus formation caused pain referred only to the upper gluteal region. These cases seem to show that even acute *intra-articular lesions do not cause pain to be referred to the anterior dermatomes unless they can produce an increase in the tension of the extra-articular ligaments.*

Case 3. J. K., a white man, thirty years of age, sustained a crushing injury to the pelvis when the main pole of a hay derrick fell upon him. At the time of our examination, six weeks after the accident, he complained of pain in both buttocks, in the right posterior and lateral femoral regions, and in the right groin.

Roentgenographic Examination: There was revealed a fracture of the sacrum on the left side, which ran through the sacral foramina. There was widening of both sacro-iliac joints. When the patient was lying supine, the right side of the symphysis pubis was displaced downward one centimeter in relation to the left. This asymmetry was reduced to one-half a centimeter when the weight was borne equally on the two feet. The two sides of the symphysis resumed their normal relationship when all of the weight was borne on the right foot.

Course: The pelvis was restored to its normal alignment by manipulation, with the patient under spinal anaesthesia. Alignment was maintained by traction applied to both legs for a period of two weeks; then the sacro-iliac joints were supported by a trans-sacral, tibial bone graft. The patient was relieved of pain by the manipulation and traction. He made an uncomplicated recovery from the operation and left the hospital on the twenty-fourth postoperative day. Three months after operation, a cyst developed about the left end of the graft where it entered the lateral aspect of the ilium just below the posterior-superior spine. The development of this cyst was accompanied by pain radiating through the left buttock to the posterior femoral and crural regions. This pain was relieved immediately by simple excision of the cyst which was found to lie beneath the long posterior sacro-iliac ligament. Pathological examination of the cyst showed it to be filled with clear, yellowish fluid in which floated myriad flecks of fibrin. Cultures of this fluid showed no growth. Sections of the wall of the cyst showed only cicatricial connective tissue. Two and one-half months later, a similar cyst developed at the opposite end of the graft where it emerged from the lateral aspect of the right ilium beneath the long posterior sacro-iliac ligament. The development of this cyst caused telalgia in the

right buttock, posterior femoral region, and calf. Simple excision of this cyst again relieved the pain. Cultures and pathological examination of the second cyst were of no more help in determining its origin than they were in the case of the first. One month after the removal of the second cyst, the patient was back at heavy labor. His progress has been followed for more than three years since his return to work, and there has been no further formation of cysts.

CASE 4. J. M., a white man, thirty-four years of age, came to us for relief from recurring attacks of pain in the lower back, with radiation to the right lateral femoral region, leg, and ankle. These attacks had started with an injury thirteen months before our first examination and had continued almost without cessation.

Roentgenographic Examination: An incomplete fusion of the pedicle of the left inferior articular process of the fifth lumbar vertebra, with a partial spondylolisthesis, was disclosed.

Physical Examination: A subluxation of the right sacro-iliac joint was found.

Course: This subluxation was reduced by manipulation without anaesthesia, and all radiating pain ceased immediately. The right sacro-iliac joint remained relaxed and sore, and, when a six-weeks' period of conservative treatment had failed to improve this condition, we were obliged to support the sacro-iliac joints by means of a trans-sacral, tibial bone graft. The patient was discharged from the hospital two weeks after operation and returned to heavy labor at his usual occupation in four and one-half months. Sixteen months after operation, the patient developed pain in the right sacro-iliac region, which radiated to the right posterior femoral region, the right lateral crural region, the ankle, and the great toe. This pain could be produced or aggravated by pressure upon the right end of the graft which projected slightly at its point of emergence from the ilium. A cordlike structure could be felt at this point, which, when rolled between the examiner's finger and the graft, "telegraphed" the pain down the leg to the ankle. An injection of 2 per cent. procaine at this point was accompanied by a temporary aggravation of the radiating pain. This was followed by relief from all symptoms, which lasted for more than one hour. Because of the success of this diagnostic test, we hospitalized the patient and explored the right end of the graft. No definite pathological process was found in the graft, in the periosteum, in the ligaments, or in the muscles. The long posterior sacro-iliac ligament was freed subperiosteally for one or two inches in all directions from the end of the graft, and the wound was closed. On the day after the operation, the patient was up and about the ward, completely free from symptoms. On the fourth postoperative day, the patient suddenly developed a subperiosteal hematoma in the operative wound. The tension of this hematoma caused a return of symptoms exactly like those of which the patient had complained before operation, and evacuation of the hematoma immediately relieved these symptoms. Because of continued hemorrhage, the wound was packed tightly. Tight packing caused the same telalgia, and the removal of the packing relieved it. The patient made an otherwise uneventful recovery and returned to his usual occupation in one month. There were no further recurrences in a two-year follow-up.

These two cases seem to show that *typical telalgia can be caused by a simple increase in the tension of the posterior sacro-iliac ligaments and the periosteum to which they are attached.* With the two cases recently reported by Heyman, in which "sciatic pain was relieved promptly and permanently by subperiosteal stripping of the gluteus maximus muscle and ligaments from the posterosuperior spine of the ilium", they seem to show that surgical release of this pathological tension stops the telalgia.

SUMMARY

1. The authors have attempted to present the syndrome of sacrarthrogenetic telalgia and to locate the origin and to trace the course of each of its components.

2. Five outstanding sources of confusion in the literature dealing with sciatica and low-back pain are:

a. The inaccuracy of the nomenclature of referred pain.
b. The influence of inaccurate nomenclature on pathological concepts.
c. The difference of opinion in regard to the localization of dermatomic areas.
d. The lack of specific descriptions of the innervation of the upper sacral joints and their ligaments.
e. The vague descriptions of tenderness of various anatomical structures.

3. In presenting the results of their clinical and anatomical research, the authors have included only those findings which are related to each of the sources of confusion.

CONCLUSIONS

1. The term "sacrarthrogenetic telalgia" accurately describes the syndrome of pain which originates in the sacro-iliac and sacrolumbar articulations and their accessory ligaments. The referred pain (telalgia) affects the gluteal or the sacral region, or both regions, and may affect any part or all parts of the lower extremities and genito-inguinal regions except the internal crural and plantar regions. The lesions that produce this type of pain are associated with lateral spinal scoliosis. They do not cause objective neuropathological manifestations other than reflex physiopathic disorders and the atrophy of disuse.

2. Sacrarthrogenetic telalgia is not the result of irritation or compression of the trunks of peripheral nerves and must not be confused with radiculitis, neuritis, or neuralgia.

3. When caused by intra-articular lesions of the upper sacral joints which do not affect the extra-articular ligaments, telalgia appears only in the intergluteal triangle.

4. Pathological changes in the tension of, or irritative stimuli applied to, the extra-articular ligaments of the upper sacral joints cause telalgia in the lower extremities.

5. Telalgia that affects the lateral crural region originates in the posterior sacro-iliac and sacro-ischial ligaments.

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A METHOD OF BLIND PEGGING FRACTURES OF THE NECK OF THE FEMUR, USING A SMITH-PETERSEN NAIL OR A BONE GRAFT AS A MEANS OF INTERNAL FIXATION

BY WILBUR J. COX, M.D., SAN FRANCISCO, CALIFORNIA

The following method has proved very satisfactory in fixing recent fractures of the neck of the femur with a Smith-Petersen nail or an autogenous bone graft. The success of this method, as of many other blind methods described in the literature, depends on the accurate insertion of a test pin from the base of the trochanter to within a few millimeters of the articular surface of the head to act as a guide.

TECHNIQUE

After x-rays have been taken of both hips, with the anteroposterior roentgenogram of the normal hip taken in extreme internal rotation, the patient is placed on a Hawley table with the buttock on the injured side resting on a cassette tunnel. The uninjured lower extremity is placed in traction to fix the pelvis. The fractured hip is manipulated by the modified Leadbetter method. The author has found this method of manipulation to be most satisfactory in the reduction of such fractures. Check-up anteroposterior and lateral x-rays of the hip are then taken. The lateral

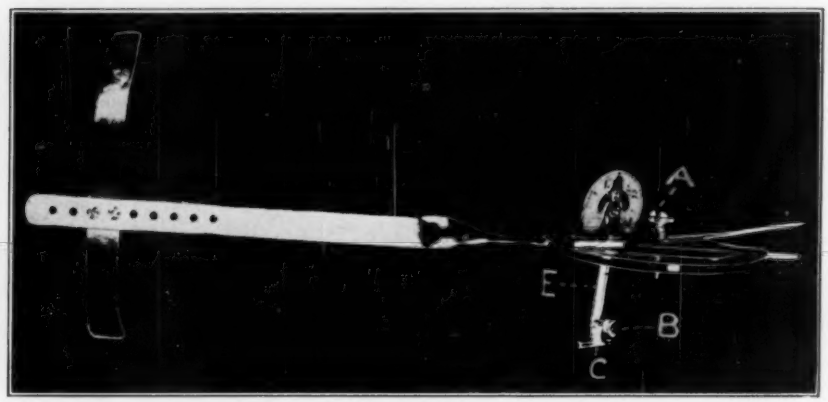

FIG. 1

Protractor assembled for left hip. By loosening the nut (*A*), the arms of the protractor may be set at the normal angle of the neck and shaft of the femur. The nut may be completely removed and the protractor may then be turned over and reassembled to fit the opposite hip. By loosening the set screw (*B*), the arm (*C*) can be raised or lowered, so that the test pin can be started midway from the anterior and posterior borders of the base of the greater trochanter. *E* indicates the lever arm.

view is taken after the method described by Leonard and George; in order to take such a view, it is necessary to remove the perineal post.

When a satisfactory reduction has been obtained, an assistant holds

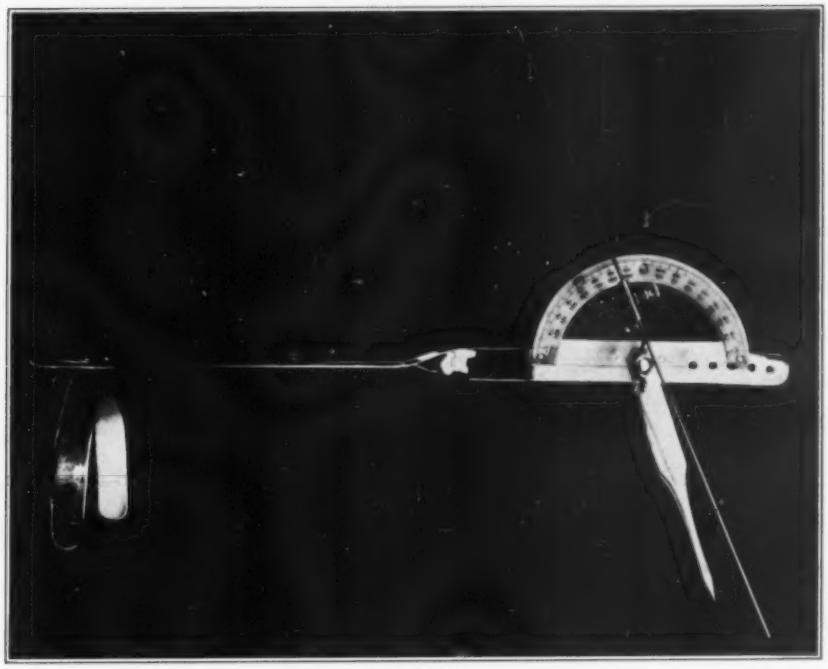

FIG. 2

Inferior view of protractor when assembled for left hip.

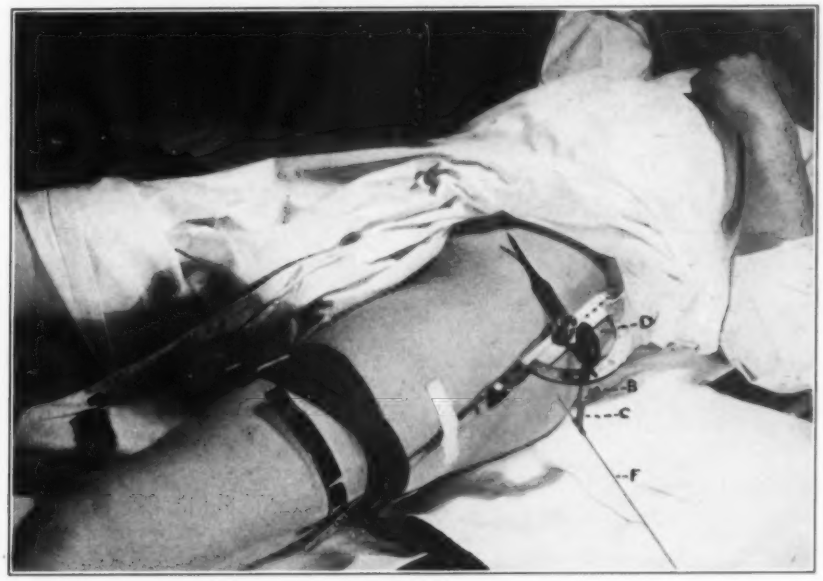

FIG. 3

Protractor placed in proper position ready for insertion of the test pin. By loosening the screw (*D*), the angle of the test pin may be changed in order to assist the operator in drilling the pin in a transverse plane. *F* indicates the Kirschner wire.

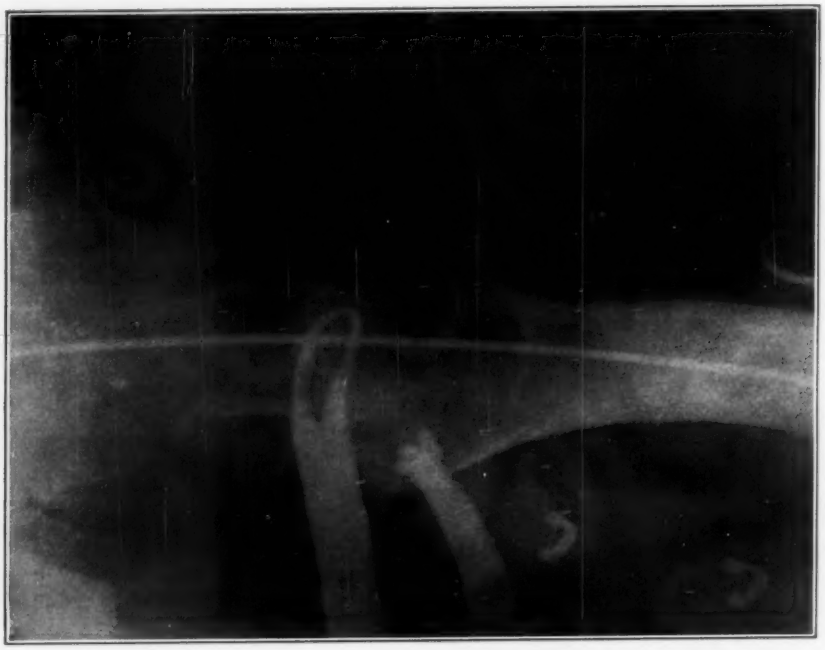

FIG. 5

Lateral view of neck of the femur, showing the test pin in proper position.

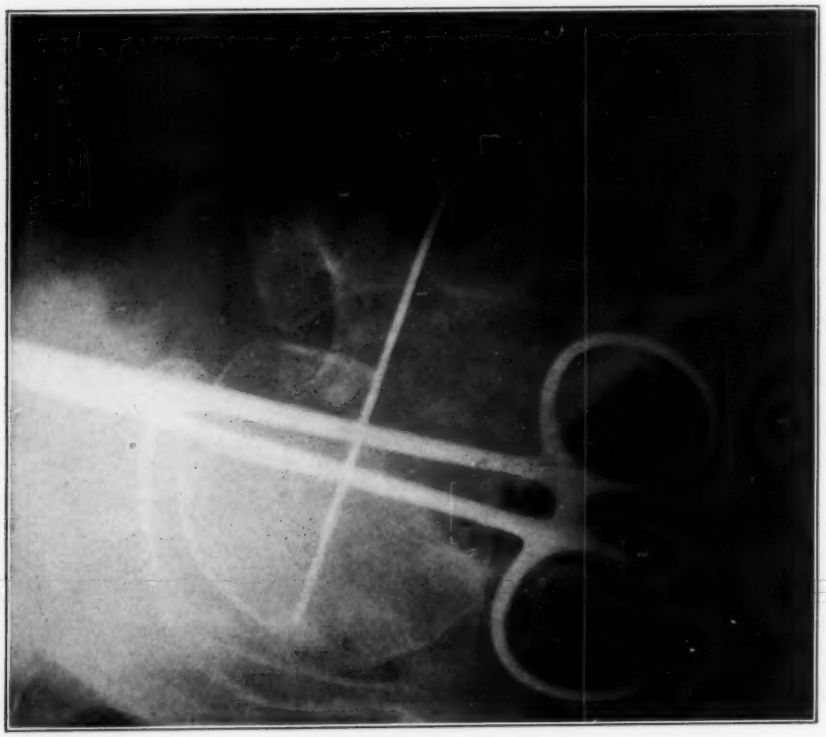

FIG. 4

Anteroposterior view of hip, showing the test pin in proper position.

the lower extremity on the injured side in abduction and marked internal rotation, and the hip joint is prepared for operation. A four-inch incision is then made, exposing the base of the trochanter. The writer uses a special protractor (Figs. 1, 2, and 3) as a means of introducing the test pin into the neck of the femur. After the normal angle of the neck and the shaft of the femur has been measured from the x-rays of the uninjured hip, taken in internal rotation, the arms of the protractor are set at the same angle. The protractor is then placed in proper position on the anterior surface of the hip with the hole which admits the test pin opposite the base of the trochanter and midway between the anteroposterior borders. The test pin is then threaded through the hole and drilled into the neck and head of the femur in a horizontal plane for a distance of nine centimeters.

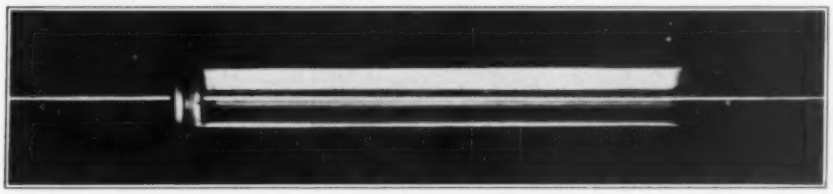

FIG. 6

Smith-Petersen nail with a hole drilled in the cap just off center and a Kirschner wire threaded through it.

One does not have to pay any attention to the angle of torsion or anteversion, as, when the lower extremity is abducted and markedly rotated internally, the neck of the femur is in a horizontal plane. The position of the test pin is then checked with anteroposterior and lateral roentgenograms of the neck of the femur. Figures 4 and 5 show the test pin in proper position.

If a bone graft is to be used as a means of internal fixation, it is imperative to drill the test pin as closely through the center of the neck as possible, but, if a Smith-Petersen nail is to be used, it makes no difference whether the test pin is on the superior or inferior side of the center of the neck, as long as the lateral view shows it to be in good position. This is one disadvantage of a hollow Smith-Petersen nail. The writer uses a Smith-Petersen nail with a hole drilled in the cap, and the end of the test pin can be threaded through the hole. In this way, the nail can be rotated about the pin and driven into the neck parallel with the pin on either the superior or the inferior side, thus compensating for the fact that the test pin is not in the center of the neck.

It is very important to use a nail of the proper length. If it is too long, it will penetrate the head; if it is too short, the fragments will not be properly fixed. The length of the nail to be used depends upon the relation of the end of the test pin to the articular surface of the head of the femur. If, when drilled into the neck for a distance of nine centimeters, the test pin just touches the articular surface of the head, an eight-centi-

FIG. 8

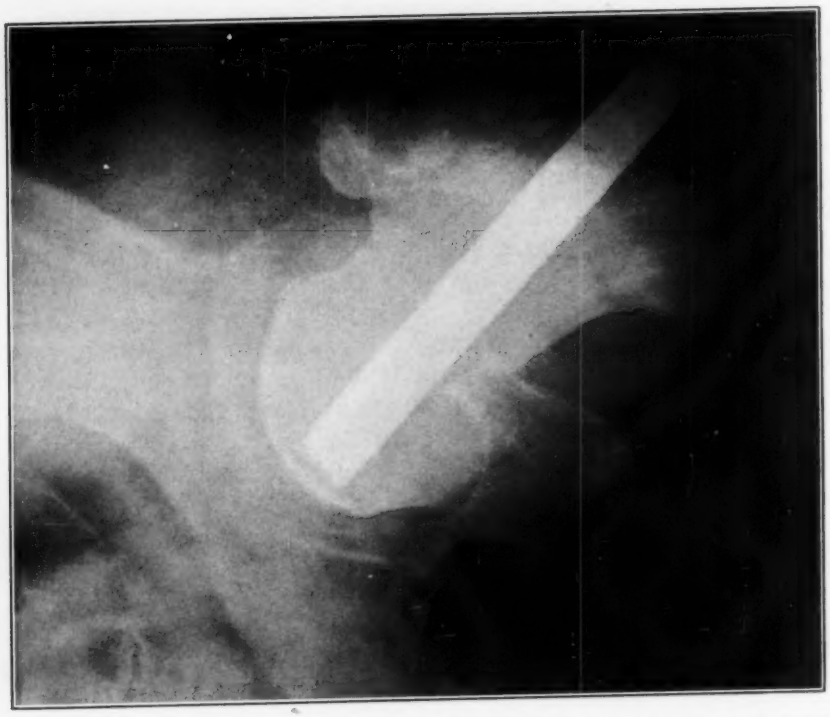

FIG. 7

meter nail should be used; if the test pin does not penetrate deeply enough into the head when drilled in nine centimeters, a ten-centimeter nail should be used. That is why nine centimeters has been adopted as the distance for drilling the test pin. It has been the writer's experience that it is necessary to use a nine-centimeter nail more frequently than any other length. A nail starter should be used before the nail is driven home; otherwise the greater trochanter is liable to be fractured. Also, in driving the nail, one should strike with moderate force, following through with the force as when driving a golf ball. The writer feels that this is very important, because, if light taps are made on the nail, distraction of

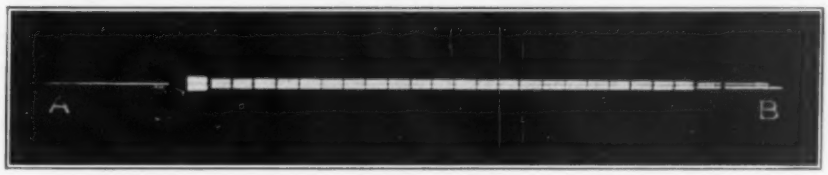

FIG. 9

Hollow drill graduated in centimeters.
A: Kirschner wire threaded into the drill; *B:* Fits into the Albee electric motor.

the fragments will result. The author has recently seen three cases in each of which there had been a perfect reduction of the fracture, followed by distraction of the fragments when the nail was driven home, because of light tapping. After the nail is driven home, the fragments are impacted and the wound is closed. Figures 7 and 8 show a fracture of the neck of the femur which has been fixed by this method.

In case a bone graft is to be used as a means of internal fixation, the graft bed is prepared by drilling a hole half an inch in diameter through the neck of the femur by threading the test pin into the hollow drill as shown in Figure 9.

Eighteen fractures of the neck of the femur have been fixed with Smith-Petersen nails by the method described, without any complication which can be attributed to the method. The youngest patient was fifty and the oldest, eighty-four.

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SOME ORTHOPAEDIC FINDINGS IN NINETY-EIGHT CASES OF HEMOPHILIA *

BY HENRY BASCOM THOMAS, M.D., CHICAGO, ILLINOIS

From the University of Illinois, College of Medicine, Chicago

Hemophilia, a sex-linked, hereditary disease limited to the male sex, is characterized clinically by excessive hemorrhage which may occur from any part of the body. The only constant abnormal laboratory finding is a prolongation of the coagulation time of the blood. The most characteristic location of hemorrhage is into the joints; for this reason, a large number of hemophiliacs consult orthopaedic surgeons.

From the standpoint of joint treatment, there is little to be said except from a conservative point of view,—that is, injury to the joints should be avoided and those joints already involved should be put at rest. In the acute stage, the application of ice bags seems to lessen the pain, to reduce the swelling, and to shorten the duration of invalidism. If the hemorrhage is extensive, the arterial pulsation distal to the involved part should be carefully watched, for, if the arterial pressure is lowered by loss of blood and the extravascular pressure is increased by the swelling, the blood supply to the distal part may be cut off and a nutritional gangrene may develop (Fig. 1). If the pulsation in the

FIG. 1-A

FIG. 1-B

Case 4, F. H. Gangrenous foot which followed extensive hemorrhage of the leg. No surgical interference; gangrenous portion sloughed spontaneously without hemorrhage.

Fig. 1-A: Photograph taken early in March, showing extent of the gangrene.

Fig. 1-B: Photograph taken seven months later after spontaneous sloughing of gangrenous portion.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

extremity is greatly diminished or entirely cut off, blood transfusion is indicated to restore the blood volume and to raise the blood pressure.

In the chronic stage, after contracture has occurred, the treatment should be directed toward overcoming the contracture and restoring function to the joint. This treatment consists of very slow traction, careful diathermy, gentle massage, and closely observed casts and turnbuckles, followed by slow and cautious institution of motion. Such treatment frequently requires many months. The injured joints are kept at rest, first in bed, later by casts, then by the use of crutches, and still later by the aid of a cane. These corrections cannot be hurried for fear of producing another hemorrhage into the same joint, which means beginning the entire process over again.

FIG. 2

Case 7, M. Z. Volkmann's contracture following extensive hemorrhage which included the entire arm.

From 1930 to 1935, ninety-eight cases * of hemophilia were studied at the Research and Educational Hospital and the Illinois Surgical Institute for Children. The findings are included in Table I.

At the time of the first examination, the ages of the patients ranged from birth to sixty-five years. Seventy-seven patients (78.5 per cent.) gave a history of joint involvement, while sixty (61.2 per cent.) had permanent joint deformity. The percentage of joint involvement is actually much higher than these figures would indicate because in the average case it is a rather late manifestation, and many of these patients are young children who undoubtedly will later develop joint hemorrhage. Of the sixty-five patients ten years of age and over, fifty-two (80 per cent.) gave a history of joint involvement. Of the joints involved, the knee was by far the most commonly affected (68 per cent.). Next in order of frequency were the ankle (56 per cent.), the elbow (53 per cent.), the hip (16 per cent.), and then, more rarely, the small joints,—the fingers (15 per cent.), the wrist (5 per cent.), and the toes (2 per cent.). The shoulder seemed to have escaped permanent deformity more than any other joint. The spine was involved in three cases.

The patient in Case 1 suffered his first joint hemorrhage at the age of three months, while the patient in Case 2 developed his earliest intracapsular hemorrhage at twenty-three years of age. These two patients were the youngest and the oldest in the group to develop hemarthrosis.

* The clinical and genetic aspects of this same group of cases have been covered in a monograph by Dr. Carroll L. Birch of the University of Illinois, College of Medicine.

TABLE I

SUMMARY OF JOINT INVOLVEMENT IN NINETY-EIGHT CASES OF HEMOPHILIA

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
1. L. S.	8 years	Elbow, at 3 months	Elbow, at 3 months	Practically all joints	Knees, elbows
2. J. M.	52 years	Bit tongue, at 5 years	Knee, at 23 years	Knees, elbows, ankles, fingers	Knees, elbows
3. L. B.	22 years	Bruises, at 6 months	Ankle, at 3 years	Practically all	Knees, elbows
4. F. H.	9 months	Hematoma, at birth	None	None	None
5. L. H.	30 years	Tooth, at 1 year	No recollection	Practically all	Practically all joints, complicated by arthritis deformans
6. H. P.	11 years	Circumcision, at 12 months	Right knee, at 4 years	Knees, spine	Spine
7. M. Z.	21 years	Circumcision, at 8 days	Hip, at 6 years	Practically all	Hips, elbows, knees, ankles, wrist, hand
8. C. L.	26 years	Subcutaneous, at 8 months	Knee, at 5 years	Practically all	Hips, knees, elbows, wrists
9. W. K.	15 years	Bruises, at 6 months	Right knee, at 5 years	Practically all	Elbows, knees, left hip
10. E. B.	19 years	Swelling of hand, at 6 months	Hips, at 4 years	Knees, ankles, elbows	Knees, elbows, ankles
11. R. R.	49 years	Knee, at 3 years	Knee, at 3 years	Knees, ankles, elbows	Knees, ankles, elbows
12. L. C.	31 years	Teeth, at 6 years	Knee, at 6 years	Ankles, knees, elbows	Ankles, knees, elbows
13. M. B.	47 years	Bit tongue, at 5 years	Knee, at 6 years	Practically all	Right knee, right hand, elbows
14. W. R.	34 years	Cut head, at 8 months	Ankles, at 3 years	Hips, ankles, knees, elbows	Knees, elbows
15. E. C. L.	12 years	Hematoma, at 3 months	Knee, at 3 years	Elbows, knees, ankles	Knees, elbows
16. W. P.	32 years	Hematoma, at 1½ years	Wrist, at 6 months	Practically all	Knees, elbows
17. F. R.	10 years	Cutting of teeth, at 10 months	Ankle, at 1½ years	Knees, ankles, elbows	Knees, elbows
18. R. R.	18 years	Umbilicus, at birth	Ankle, at 18 months	Knees, ankles, elbows	Knees, elbows

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
19. J. R.	34 years	Knee, at 6 years	Knee, at 6 years	Practically all	Knees, elbows
20. H. Z.	16 years	Circumcision, at 8 days	Ankle, at 7 years	Practically all	Knees, elbows
21. J. W.	37 years	Subcutaneous, at 5 days	Knee, at 6 years	Practically all	Knees, elbows
22. L. H.	11 years	Hand, at 4 months	Elbow, at 3 years	Wrist, ankles, elbows, knees	Knees, elbows
23. E. K. L.	30 years	Ankle, at 3 years	Ankle, at 3 years	Practically all	Knees, elbows
24. H. H.	10 years	No recollection	Ankle, at 4 years	Ankles, elbows, knees, shoulders	Knees, elbows
25. M. H.	12 years	Bruises, at 8 months	Knee, at 3 years	Ankles, elbows, knees, shoulders	Knees, elbows
26. R. M.	18 years	No recollection	Elbows, at 18 months	Ankles, knees, elbows, wrists, fingers	Knees, elbows
27. W. G.	20 years	No recollection	Elbows, at 18 months	Knees, elbows	Knees, elbows
28. J. A.	7 years	Foreskin stretched, immediately after birth	Wrist, at 2 years	Knee, wrist, elbows	Knee, elbows
29. J. O.	18 years	Skin, at 5 months	Elbow, at 4 years	Practically all	Knee, elbow
30. R. T.	14 years	Circumcision, at 8 days	Elbow, at 11 years	Elbows, knees, ankles, wrists	Knee, elbow
31. J. K.	17 years	Circumcision, at 6 weeks	Knee, at 6 years	Practically all	Knee, hips
32. R. W.	17 years	Circumcision, at 8 days	Knee, at 6 years	Knees, elbows, hips, shoulder	Knee, hip
33. J. W.	22 years	Circumcision, at 8 days	Knee, at 4 years	Practically all	Knee, shoulder
34. W. U.	10 years	Circumcision, at 9 days	Elbow, at 5 years	Elbows, knees, hips, shoulders	Knees
35. J. H.	13 years	Circumcision, at 9 days	Knee, at 4 years	Knees, elbows	Knees
36. J. J.	30 years	Knee, at 10 years	Knee, at 10 years	Practically all	Knees
37. R. J. M.	35 years	No recollection	No recollection	Knees, ankles, elbows, hips	Knees
38. S. S.	28 years	Circumcision, at 8 days	Knee, at 10 years	Knees, ankles, elbows	Knees

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
39. D. F.	13 years	Circumcision, at 4 weeks	Hip, at 5 years	Knees, hips, wrists, ankles, fingers	Knees
40. J. S.	22 months	Circumcision, at 12 days	Knee, at 14 months	Knees	Left knee
41. L. B.	2½ years	Hematoma, at 9 months	Knee, at 18 months	Knees	Knee
42. S. C.	13 years	Cut finger, at 6 months	Knee, at 1 year	Knees, elbows, ankles	Knee
43. H. Z.	6 years	Finger, at 13 months	Knee, at 18 months	Knees	Knee
44. R. S.	8 years	Tongue cut, at 7 months	Hip, at 5 years	Shoulders, knees, ankles	Knee
45. F. O.	7 years	Tooth, at 10 months	Knee, at 6 years	Knee	Knee
46. H. W.	15 years	No recollection	No recollection	Knee	Knee
47. S. M.	22 years	No recollection	Knee, at 14 months	Knees, elbows, fingers, hips	Elbows, hips, ankles
48. B. E.	14 years	Cutting of tooth, at 6 months	Ankle, at 4 years	Ankles, knees, elbows, right hip	Elbows, ankle
49. J. P.	16 years	No recollection	Elbow, at 7 years	Elbows, knees, ankles	Elbows, ankles
50. E. C.	11 years	Bit tongue, at 13 months	Spinal column, at 2 years	Ankles, knees, shoulders, hips, spine, elbows	Elbows
51. J. S.	8 years	Circumcision, at 8 days	Elbow, at 3 years	Elbows, ankles, knees	Elbows
52. L. B.	11 years	Bruises, at 6 months	Elbow, at 5 years	Elbows, ankles, knees	Elbows
53. G. L.	30 years	Hematoma, at 6 months	Elbow, at 5 years	Elbows, hips, knees, fingers, toes	Elbows
54. D. M.	6 years	Cut lip, at 3 years	Elbow, at 5 years	Elbows	Elbow
55. B. C.	14 years	Cut finger, at 6 months	Elbow, at 9 years	Knees, ankles, wrists	Left elbow
56. J. F.	6 years	Cut lip, at 1 year	Ankle, at 3 years	Ankles, elbows	Left elbow
57. M. B.	65 years	Teeth, at 6 years	Elbow, at about 40 years	Elbow	Left elbow
58. S. R.	12 years	Subcutaneous, at 4 months	Ankles, at 2 years	Ankles, knees, elbows, shoulders, toes, fingers	Elbows, knees

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
59. J. G.	12 years	Knee, at 6 years	Knees, at 6 years	Shoulders, knees, ankles	Knee
60. C. F.	58 years	No recollection	No recollection	Knees	Knees
61. A. G.	11 years	Cut finger, at 5 years	Ankle, at 6 years	Ankles, knees, elbow	Knee
62. B. S.	8 years	Hematoma, at 1 year	Knee, at 2 years	Elbow, knee, ankles, hip	None
63. D. S.	9 years	Hematoma, at 6 months	Knee, at 2 years	Knees, ankles, elbows	None
64. R. C.	4 years	Umbilicus, at birth	Ankle, at 18 months	Ankles, knees	None
65. R. B.	4 years	Bit lip, at 10 months	Shoulder, at 3 years	Ankle, knee	None
66. J. O.	27 months	Circumcision, at 10 days	Ankle, at 2 years	Ankle, knee	None
67. D. V.	6 years	Ankle, at 1 year	Ankle, at 1 year	Elbows, knees, ankles	None
68. H. P.	2 years	Circumcision, at 8 days	Right knee, at 15 months	Knees	None
69. A. M.	7 years	Attempted circumcision, at 8 days	Knee, at 1 year	Knees, elbows	None
70. T. S.	4 years	Hematoma, at 3 months	Spine, at 4 years	Spine	None
71. G. W.	4 years	Cut lip, at 1½ years	Left ankle, at 4 years	Left ankle	None
72. L. B.	7 years	Nosebleed, at 9 months	Left elbow, at 5 years	Ankles, elbows	None
73. D. G.	30 years	Hematoma, at 3 months	Ankle, at 6 years	Knee, ankle	None
74. S. S.	5 years	Circumcision, at 8 days	Knee, at 3 years	Knees	None
75. T. W.	12 years	Throat, at 11 months	Ankle, at 9 years	Ankles, hips	None
76. V. L.	4½ years	Circumcision, at 5 days	Right knee, at 4½ years	Right knee	None
77. R. K.	3 years	Ankles, at 3 years	Ankles, at 3 years	Ankle	None
78. P. W.	2½ years	Circumcision, at 9 days	Ankle, at 1 year	Ankle	None

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
79. R. R.	7 months	Circumcision, at 8 days	None	None	None
80. R. Z.	1 year	Bruises, at 3 months	None	None	None
81. T. S.	40 years	Cut lip, at 18 months	None	None	None
82. W. G.	37 years	Teeth, at 1 year	None	None	None
83. J. M.	11 years	Baby teeth	None	None	None
84. D. C.	24 years	Teeth, at 1 year	None	None	None
85. P. D.	8 years	Nosebleed, at 2 years	None	None	None
86. M. F.	16 years	Nosebleed, at 3 years	None	None	None
87. E. K.	6 years	Teeth, at 6 months	None	None	None
88. D. K.	Birth	Umbilical cord, at 4 days	None	None	None
89. C. L.	22 years	Adenoids removed, at 4 years	None	None	None
90. E. P.	12 years	No recollection	None	None	None
91. T. S.	14 years	Nasal, at 2 years	None	None	None
92. J. S.	11 years	No recollection	None	None	None
93. P. S.	12 years	No recollection	None	None	None
94. K. T.	8 years	Nosebleed, at 2 years	None	None	None
95. K. T.	8 years	Nosebleed, at 2 years	None	None	None
96. W. Z.	17 years	Nosebleed, at 2½ years	None	None	None
97. Q. R.	11 years	Nasal, at 2 years	None	None	None
98. H. F.	18 years	Circumcision, at 9 days	None	None	None

Case 3 is of special interest to the author because in 1930 he performed an ovarian transplantation on this boy. There was no excessive bleeding at the time of operation and the patient remained symptom-free for five and one-half months. Following this, he also suffered two fractures of the femur, both of which healed surprisingly well, so that a satisfactory leg resulted. It is of interest that this patient's maternal grandfather bled to death following a fracture of the leg.

From birth, the patient in Case 4 bruised easily. At nine months of age the diagnosis of hemophilia was made by blood examination. He is a member of a high-grade hemophilic family. His maternal uncle is also included in the group of cases reviewed in Table I. Three other maternal uncles have bled to death. In February 1934, the patient suffered a small two-inch burn on the external aspect of the leg between the knee and ankle. This was followed by extensive hemorrhage which included the whole extremity. He became very anaemic and ran a high temperature. Three weeks later, when the swelling and discoloration began to subside, it was found that the foot was gangrenous (Fig. 1-A). At this time, the patient received two blood transfusions. It was in this condition that he was brought to the hospital. Pneumonia developed and three blood transfusions were given. Nothing was done to the foot and no bandages were applied. The affected area was left exposed and was merely protected from external injury. When the gangrenous portion became loosened, it was strapped on with adhesive tape. After seven months, there was a spontaneous sloughing of the entire portion of the foot without the loss of a single drop of blood (Fig. 1-B). This is the only case of hemophilia with gangrene which the author has observed.

The patient in Case 5 has a combination of generalized proliferative arthritis and hemophilic hemarthrosis. Practically all of the joints are involved and many are permanently deformed. He has been confined to a wheel chair for six years.

In Case 6 there is a definite destruction of the spine which undoubtedly followed a hemorrhage in this location. The case was first diagnosed as Pott's disease and the patient was kept on a frame for two years.

The patient in Case 7 has a Volkmann's contracture following extensive hemorrhage which involved the entire arm (Fig. 2).

The patient in Case 34 has suffered so many hemorrhages into his knee that he has been able to walk but nine months during the last five years. The patients in Cases 94 and 95 are twins.

CONCLUSIONS

General or constitutional treatment of hemophilia presents a chaos of conflicting opinions, out of which the internist may perhaps bring order. The present study, showing the high percentage of joint involvement, demonstrates that the orthopaedic surgeon has an interest in the patient with hemophilia and may have an important rôle to play in the early management of these cases and in the surgical rehabilitation of deformed joints, if and when a means for the control of hemorrhage is found.

CONGENITAL ANOMALY OF THE CORACOID

Os Coracosternale Vestigiale

BY JEROME G. FINDER, M.D., IOWA CITY, IOWA

From the Department of Orthopaedic Surgery, Children's Hospital, Iowa City
Service of Arthur Steindler, M.D.

Congenital anomalies of the coracoid portion of the human scapula are very rare. The following case of a vestigial coracosternal bony process represents an unusual anomaly in man. As far as can be determined, this particular anomaly has never been reported before. In this instance, it was associated with other congenital defects,—namely, spina bifida of the cervical region, Sprengel's deformity, and torticollis.

CASE REPORT

The patient was first seen on February 13, 1934, when seven months old. He had been delivered of an eclamptic, primiparous mother by Caesarean section. Shortly after, a prominence of the right clavicle (?) had been noted, associated with some twisting of the head toward the left side. The torticollis increased and the patient did not use the right arm very actively.

Physical Examination (September 19, 1934)

Only the factors relevant to the congenital defects are recorded here.

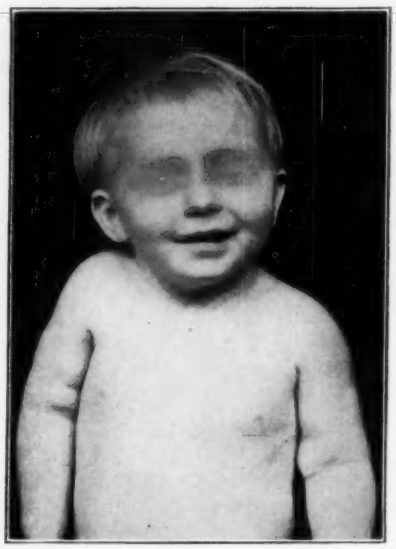

FIG. 1

Front view of patient, aged nineteen months, showing the facial asymmetry, torticollis, and elevation of the right shoulder.

FIG. 2

Posterior view of patient, revealing the rotation of the head, the low hair line, the elevation of the right shoulder, and the winged, elevated right scapula.

Head and Neck: The anterior fontanel had a small patency; the posterior suture was closed. A moderately advanced torticollis existed,—occiput right and face directed to the left. Facial distortion was also evident, with the convexity to the left (Fig. 1). The hair line posteriorly was short and low, simulating that of the Klippel-Feil syndrome (Fig. 2).

Despite the torticollis, there was no particular tension of the right sternocleidomastoid muscle, but there was a definite band of tense structures in the direction of the levator scapulae muscle and the upper fibers of the trapezius muscle. Movements of the head and neck were fairly free except for rotation and lateral flexion to the right.

Shoulder Girdle: The right shoulder was definitely elevated (Figs. 1 and 2) and associated with a high scapula which "winged out" moderately. Voluntary movements of the right arm were free in all directions, although the patient was disinclined to use the extremity. At the junction of the middle and outer thirds of the clavicle, a sharp bony projection protruded upward and medially. This projection was easily palpable under the skin and was visible when the child's head was rotated to the left (Fig. 3).

FIG. 3

The head is turned to the left to bring out the bony prominence (indicated by the arrow) caused by the coracosternal bone of the right side.

Roentgenographic Examination

The neural arches of the third to seventh cervical vertebrae inclusive showed incomplete closure (Fig. 4). The entire right scapula was elevated and showed hypertrophy of the upper border. The acromion, coracoid, and the distal end of the clavicle were malformed. An elongated, tapering bony structure arose from the base of the coracoid, medial to the glenoid fossa. It was directed upward and medially, being definitely separated from the cervical spine by a distance of at least one inch (stereoscopic reading). This structure was also separate and distinct from the spine of the scapula, the direction of which was about 45 degrees closer to the horizontal.

Diagnosis

1. Spina bifida occulta cervicalis.
2. Scapula alata dextra (Sprengel's deformity).
3. Torticollis.
4. Os coracosternale vestigiale.

DEVELOPMENTAL ANATOMY

According to Broom, in 1897, marsupials showed a phylogenetic connection between the coracoid and the sternum. Ontogenetically, he found this relationship in early stages; in older embryos, however, the medial portion of the coracoid degenerated and lost its connection with the sternum.

Gegenbauer, Parker, and Bütschli found that in certain of the gnawing animals there was a small bone contiguous to the first rib and the

sternum, and these authors considered this bone to be an arrest of the medial portion of the coracoid. On the other hand, certain authors, such as Nauck and Vialleton, claimed that higher mammals had no coracoid at all, but that it was a new formation phylogenetically. This statement, however, probably is incorrect, because Subkowitsch demonstrated the existence of a coracoid in young human embryos as well as in bats.

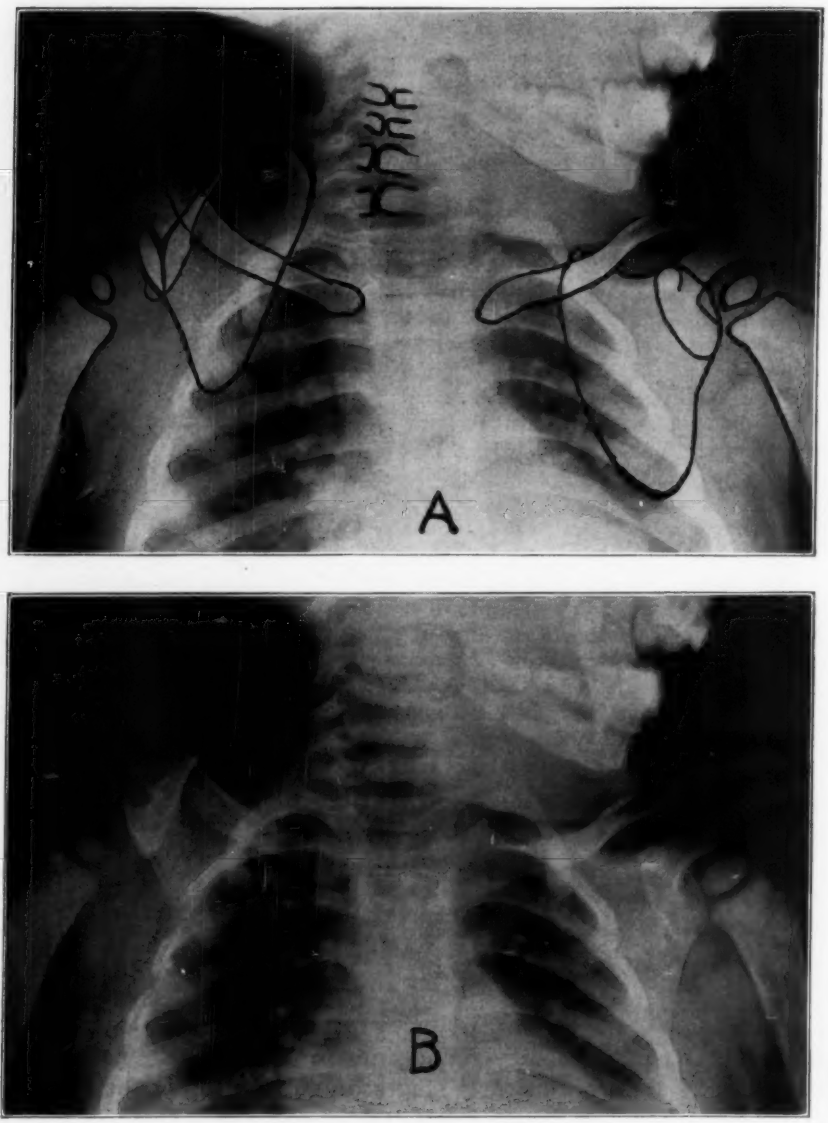

FIG. 4

The main defects have been accentuated in *A* by black outlines; the normal left scapula is also touched up for comparison. The unaltered x-ray, *B*, represents the same view as *A*, taken when the patient was fourteen months old.

Subkowitsch stated that the embryos studied showed a definite connection between the coracoid and the sternum. The coracoid always developed from a base in connection with the glenoid. At the same time, a mass of mesenchymatous cells appeared and spread as a bar toward the mesenchymatous anlage of the sternum, with which it subsequently united. Somewhat later, the mesenchymatous bar divided in its long axis into an upper (cephalad) and lower (caudad) portion. These relations are nicely demonstrated in a model reconstructed from serial sagittal sections of the human embryo (Fig. 5). Still later, the cephalad layer began to disappear from its coracoid end, while the *caudad layer faded from its sternal end.* It is believed that all that remains of the mesenchymatous bar in the mature foetus is the coracoclavicular ligament, composed of a conoid and a trapezoid portion.

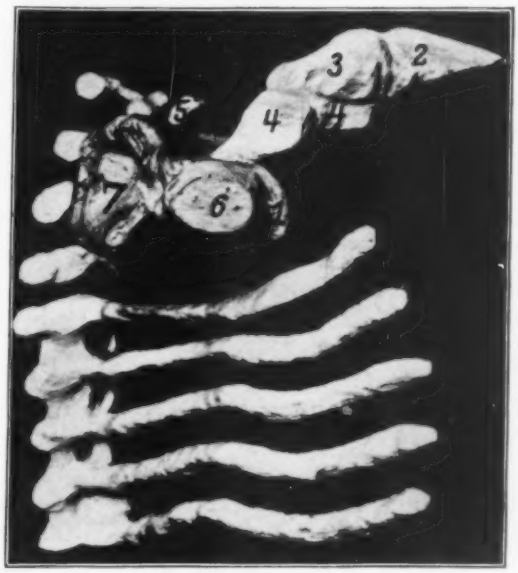

FIG. 5

The reconstructed model (after Subkowitsch), made from sagittal sections of an early human embryo, shows the lateral view of the right shoulder girdle and chest wall. The structures indicated are: coracoid process (*1*); sternum (*2*); cephalad portion of the mesenchymatous coracosternal bar (*3*); caudad layer of the bar (*4*), the lateral part of which represents the anlage of the anomaly described in this report; acromion (*5*); humeral head lying in the glenoid cavity (*6*); body of the scapula (*7*). (Reproduced from *Morphologisches Jahrbuch*, LXV, 1931, by courtesy of *Akademische Verlagsgesellschaft.*)

Since the coracosternal connection is a mesenchymatous one, the persistence of a muscle-tissue derivative in postnatal life must be considered also. Lane described an anomalous coracoclaviculosternal muscle in a powerfully built adult male. This muscle, which lay beneath the costocoracoid membrane, took origin from the whole anterior margin of the coracoid process, from a comparatively strong coracoclavicular ligament, and, to a slight extent, from the inner margin of the coracoid facet on the under surface of the clavicle. The greater part of this coracosternal muscle was fleshy and formed a muscle belly as large as that of the average normal subclavius muscle. Medially, it formed a flat tendon, about a half an inch long and an eighth of an inch wide, which inserted into the lower part of the anterior margin of the clavicular facet of the sternum. The subclavius muscle and the costocoracoid membrane were present in their otherwise normal relations.

DISCUSSION

The existence in the embryo of a mesenchymatous connection between the coracoid and sternum theoretically may furnish the basis for the persistence of a mesodermal derivative in postnatal life. It is possible for muscle, ligament, cartilage, or bone to form directly from this germ layer. The coracoclaviculosternal muscle described by Lane apparently justifies this conjecture. On the other hand, preformed tissue may degenerate and undergo fibrosis; the coracoclavicular ligament may represent such a process. As a further step, calcification and even bone formation may occur.

The associated congenital anomalies in the case reported represent developmental defects, due to the persistence of an early embryonal stage. It is, therefore, consistent to consider the persistence of the coracosternal bone in the same category as other primitive states,—namely, failure of descent of the scapula (so called congenital elevation or Sprengel's deformity) and failure of closure of the neural arches. The author believes that the anomalous bony structure in the patient whose case is reported represents the persistence of the lateral portion of the caudad layer of the mesenchymatous coracosternal bar, of which the germ cells not only failed to disappear entirely, but actually developed into a bone found normally only in mature lower animal forms. The writer would like to suggest the name *os coracosternale vestigiale* for this structure when it occurs in man.

The unilateral occurrence of all the defects indicates that some developmental derangement must have occurred in the embryo involving the upper segments of the right side. The arrest most likely occurred during the third month of intra-uterine life. This is corroborated to some extent by the scapular position, which corresponds to the level of descent in the third month of foetal life.

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UNUSUAL FRACTURES OF THE SPINE *

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The following cases of fracture of the spinal column are presented to exemplify the well known fact that, although treatment of a given condition may be well standardized, problems are always arising to which no rule of thumb can be applied. The bizarre findings and excellent end results seem to justify the making of a permanent record in these cases.

CASE 1. G. C. N., aged fifty-one, a truckdriver, sustained an injury to the lower back, with consequent paralysis of the lower extremities, as the result of an accident on April 10, 1934, in which he had been dragged by a truck and jammed into a fence. He was transported to the Vallejo General Hospital where he was placed in a fracture bed with his feet strapped to the mattress. Although conscious for the first twenty-four hours following the accident, he rapidly became increasingly stuporous and finally comatose. He was seen by the authors on the fourth day following the injury, at which time he was unable to take nourishment. He was suffering from incontinence of the bladder and rectum; his breath was strong of acetone; and, although he was in an irrational state, there were constant spastic movements of the facial muscles and the upper extremities. His blood pressure was 110/55; pulse, 110; respiration, 26.

Physical examination revealed complete paralysis of the lower extremities and slight incoordinated twitching in the adductor and abductor groups of the thighs and extensors of the knees. There was loss of reflexes in the lower extremities, and the cremasteric and abdominal reflexes were absent.

Roentgenographic examination disclosed a comminuted, compressed fracture of the body and lamina of the first lumbar vertebra, with marked lateral displacement to the left of the entire spinal column. The lower portion of the twelfth dorsal vertebra on the left side had likewise been compressed.

One week following the accident, the patient was in sufficiently good condition to be transported on a Bradford frame to San Francisco by ambulance. Five days prior to his transfer, head and leg traction had been applied, but, at the end of this time, examination failed to reveal any change either in the deformity or in the return of motion to the extremities. Sensory examination, however, revealed an irregular zone of hyperaesthesia bilaterally at the level of the twelfth thoracic segment. There were isolated areas on the right foot along the medial side near the ankle where sensation to touch was present. Pain was absent in the left leg, but present on the medial side of the right leg and foot. Deep muscle sensibility, with regard to the position of the toes, was present in both feet. Pressure on the medial side of the thighs was directly recognized. Sphincter tone was present by digital examination. A two-piece plaster jacket was applied, which was left open at the site of the fracture and made continuous by lateral boards incorporated in the two halves to give a mobile apparatus, providing for possible correction at the time of operation for the lateral displacement at the site of the fracture.

On April 19, 1934, nine days following the injury, the operation was performed through the fenestrated plaster, with the patient under avertin anaesthesia. The fracture site was exposed by the usual midline incision and subperiosteal dissection. On removal of the laminae over the involved area, the spinal cord was found to be compressed and the dura torn by a large fragment of bone. This fragment was carefully removed and sufficient bone was taken from the canal to compensate for the sharp, lateral angulation

* Presented before the San Francisco Chapter of the Western Orthopaedic Association, February 26, 1935.

FIG. 1

Case 1, G. C. N. Showing extensive fracture of the lumbar spine, with marked lateral displacement.

FIG. 2

Case 1, G. C. N. Lateral view, showing compression of the vertebral body.

FIG. 3

Case 1, G. C. N. Showing operative correction of deformity and bone grafts *in situ*.

of the cord, caused by the displacement of the vertebral body. It is interesting to note that even at this time there was considerable reaction, resulting in a deposit of fibrinous tissue which was adherent to the dura and caused sufficient contracture to compress the cord partially. This tissue was likewise removed. With the cord free, the wooden supports in the plaster were cut and the lateral displacement was easily corrected. Some difficulty, however, was experienced in maintaining alignment.

Further exploration of the cord by incision of the dura revealed no evidence of block or hemorrhage. Two tibial bone grafts were placed, one on each side, along the denuded laminae and pedicles, and the wound was closed in the routine manner.

The patient's immediate convalescence was relatively uneventful and x-rays, taken April 26, 1934, revealed the spinal column to be extended and the lateral offset between the twelfth dorsal and first lumbar vertebrae to be partially corrected. The bone grafts were *in situ*, extending from the tenth dorsal vertebra to the third lumbar vertebra.

On the tenth day after operation, the original plaster was removed and the patient was fitted with a non-padded jacket, extending from the axillae down both legs to the knees. This plaster was removed on June 13, 1934, and the patient was fitted with a Taylor spinal brace.

FIG. 4

Case 1, G. C. N. Showing fusion of grafts and maintenance of correction of deformity.

Certain features of the patient's convalescence are worthy of note. On May 2, 1934, approximately two weeks after the operation, it was noticed that there was a definite return of power to the hamstring and gastrocnemius groups, as well as the short flexors of the toes. There was slight return of power to both quadriceps groups. About this time and for the ensuing two weeks, the patient complained steadily of sharp, radiating pain over the dorsum of the feet and down the legs. This pain was accompanied by a slow, but definite increase in motor function. On May 19, 1934, a month after the operation, good power was noted in all muscle groups except the tibialis anticus and the extensor digitorum muscles in which only slight recovery was evident.

A month after the plaster had been removed and the patient had been fitted with a brace, he was allowed freedom in the bed, but no attempt was made to start him walking. During this time, physiotherapy and reeducational exercises were directed at the lower extremities. Movement in the knee joint was recovered rather quickly, but considerable difficulty was experienced in obtaining motion in the hip joints. This limitation of motion in the hip joints was a definite handicap when the patient began walking and continued to be a source of annoyance even when he was able to walk without crutches, as the limitation of flexion prevented him from sitting down and arising from a chair easily.

On August 16, 1934, four months after the operation, the patient was walking daily with mechanical aid, and a month later he was handling himself readily with crutches. He improved rapidly from that date and, by the seventh month, was discharged to a convalescent home, wearing a Taylor brace and a pair of foot-drop braces. Good function had returned to the muscles, with the exception of the dorsiflexors of the toes and the tibialis anticus muscle groups.

Ten months following the injury, examination disclosed the fusion of the graft to be complete. The patient was able to bend forward within seven and one-half inches of the floor, although the motions of the spine were somewhat limited, due to the fusion of the lumbar area. His general condition was such that he was discharged as cured on February 20, 1935.

At present, the patient is ambulatory, without a foot or back brace, is able to do light work, and has no complaints other than an occasional feeling of fatigue after excessive weight-bearing. His permanent disability consists solely of limited motion over the site of the spinal grafts.

Case 2. A. D., aged fifty-nine, an electrical inspector, on September 24, 1934, fell off a fire escape from a height of three stories and landed in the cement courtyard below. The patient's back struck a clothesline pole, which broke the speed of his descent and undoubtedly contributed to the bizarre type of fracture which he sustained.

Although in a state of considerable shock when first seen by the authors within an hour after the accident, the patient was fully conscious and complained of severe pain in the lower back. Careful neurological examination failed to reveal any evidence of motor paralysis or paresis. There was moderate distension of the abdomen with urinary retention, absence of the right patellar reflex, and presence of both ankle jerks. Plantar stimulation of the feet gave plantar flexion of both great toes. Sensation to cotton and pin was preserved in both lower extremities. No sensory level could be determined on the abdomen. Slight hyperaesthesia was present over the right perineum. Sphincter tone was good. The feet were cool and moist. Pulsations were good and equal in the peripheral arteries.

An interesting phenomenon was observed,—namely, when an attempt was made to elicit the right patellar reflex, a definite contraction was noticed in the thigh muscles of the opposite leg.

X-rays disclosed a most unusual type of fracture, best characterized by one of our colleagues who saw this patient in consultation as an "explosion" fracture.

The roentgenograms showed a comminuted fracture of the body of the fourth lumbar vertebra. The fracture had sheered off in such a way that the lower anterior portion of the body with the fifth lumbar vertebra had been displaced anteriorly, so that it lay in front of the spinal column proper, and part of it above the lower quarter of the third lumbar vertebra. The sacrum, while partially pushed forward, had not been displaced as far as the body of the fifth lumbar vertebra and, therefore, had encroached upon the space normally occupied by this vertebra. There was also a fracture of the sacrum, approximately at the level of the third segment, with the lower segment slightly anterior.

It became apparent that the injury had widened and shortened the spinal canal sufficiently to prevent the involvement of the roots of the corda equina. An attempt at closed reduction of this fracture might well result in a permanent derangement of the involved fibers of the spinal cord as well as in damage to the aorta. There was likewise relatively little chance that satisfactory reduction could be obtained by operative procedure. As the general alignment of the spine shown in the anterior, posterior, and lateral planes was relatively good, it was decided to immobilize the patient and await results. Since it was quite probable that a stable back would not result, the advisability of doing a bone-graft-fixation operation over the fractured area at a later date was given consideration.

Following the method adopted in the previous case, the plaster shell, incorporating both legs to the knees, was molded on the patient. The distention and urinary retention

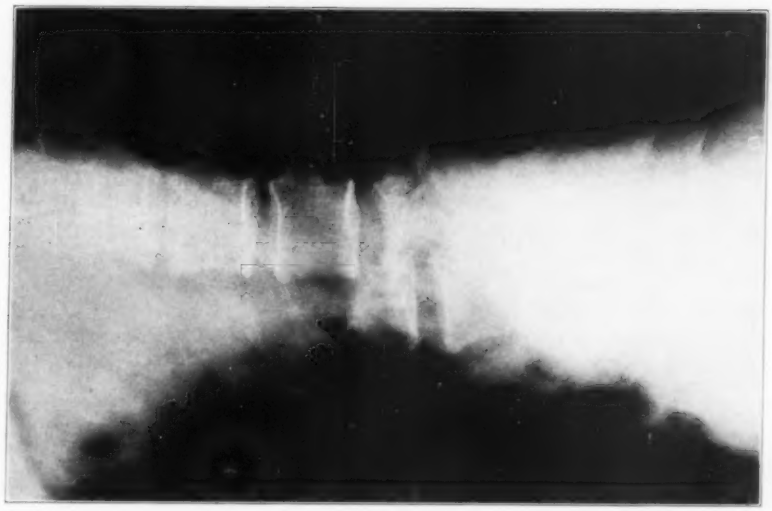

FIG. 7

Case 2, A. D. Five months later. Deformity unchanged; patient ambulatory; no symptoms.

FIG. 6

Case 2, A. D. Lateral view, showing marked displacement and "explosion" of the vertebrae.

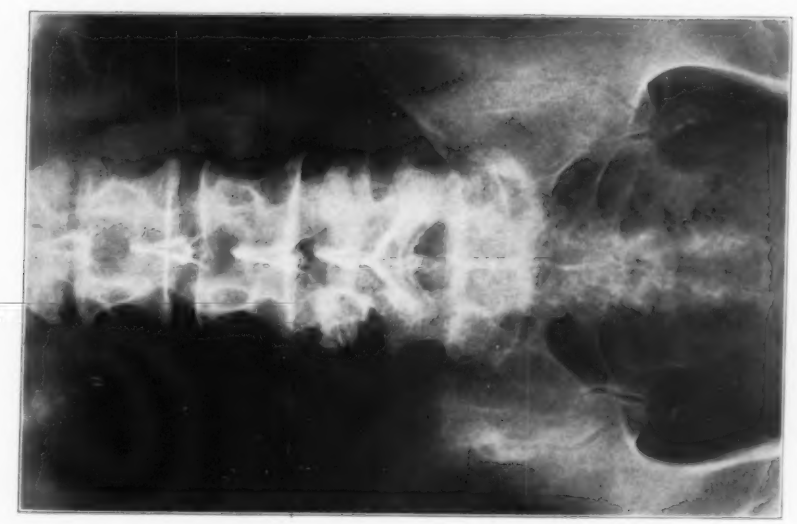

FIG. 5

Case 2, A. D. Anteroposterior view of lumbar spine, showing absence of gross deformity.

disappeared within a few days and the patient progressed in apparently uneventful convalescence.

As soon as immobilization was secure, the patient was turned frequently on the abdomen and side to avoid congestion and possible pressure sores. The authors have adopted this method as a routine measure in the treatment of spinal injuries, and they have found it to be not only a very valuable adjunct in the treatment of the condition mentioned, but also a direct prophylaxis against tympanites and its altogether too frequent companion, paralytic ileus.

The plaster was changed about the fourth week and a well fitting shell was carried to the level of the trochanters only. This plaster was retained until December 28, 1934, some three and one-half months following the accident. At this time a spinal brace was applied, new x-rays were taken, and rehabilitation exercises were started.

The oblique x-rays of the lower lumbar spine showed the fracture of the fourth and fifth lumbar bodies to be well organized, with much callus. There was no definite bony union between the sacrum and the fifth lumbar vertebra.

Exercises in bed were given for about two weeks, followed by ambulation for increasing periods. At present, the patient is up the entire day and is able to walk about without aid, to climb stairs, and to get in and out of an automobile without great difficulty. His most outstanding impediment has been the limited motion in the hip joints, which has prevented him from sitting comfortably, except in chairs of sufficient height to compensate for the loss of hip flexion. This motion is now entirely recovered, and the patient is exercising several hours a day without support of any kind. He is still wearing the spinal brace, which he is removing for increasing periods and which will shortly be dispensed with entirely. Aside from general fatigue, which is natural after his increasing activity, he has no complaints that are referable to the injury.

CONCLUSIONS

1. No standardized treatment can be adopted for complicated spinal injuries; the amount of corrective procedure necessary is dependent upon the surgeon's judgment in the individual case.

2. The combating of shock and the preservation of the patient's life take precedence over orthopaedic corrective measures.

3. The question of surgery for the alleviation of nerve injury must be decided for each case individually.

4. The restoration of anatomical position is not absolutely essential for the obtaining of a good functional result.

5. In those cases in which open operation is resorted to, it is advisable to fuse the fractured area at the time the original operation is performed.

6. Frequent turning and changing of the patient's position, as soon as adequate immobilization has been obtained, is of primary importance in avoiding complications, such as pressure sores, pulmonary changes, and ileus.

CORTICAL AVULSION FRACTURE OF THE LATERAL TIBIAL CONDYLE

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

*From the Hospital for Joint Diseases**

During the past few months, the author has had the unusual opportunity of examining several fractures of the knee in which the whole clinical picture presented such a constant and striking uniformity as to warrant grouping these fractures in a special category. At the outset, the diagnosis could be established only by means of the x-ray, but more careful study of the clinical picture has shown that the diagnosis may be ventured and should always be entertained even before the roentgenogram has been made.

The following cases are of special interest because they present in ascending order the various degrees in which the condition, cortical avulsion fracture of the tibial condyle, may be met.

CASE 1. M. P., a physician, was seen a day or two after he had misstepped and fallen on his flexed right knee. At the time of the injury, he complained of severe pain and had to be picked up and carried back into the house. After a day or two, the pain gradually subsided, but the patient noted difficulty in going up stairs.

When examined, no fluid was found in the knee and no ecchymosis was seen. There was no limitation nor abnormality of motion. There was a point of tenderness definitely

FIG. 1

Oblique anteroposterior view, showing oval shadow directly below area of tenderness.

FIG. 2

Anteroposterior view, showing cortical avulsion fracture involving the articular surface of the tibia. The head of the fibula presents its normal contours.

* Service of Harry Finkelstein, M.D.

localized over the lateral condyle of the tibia just below the articular edge in a plane midway between the tibiofibular joint and the tibial tubercle. This area corresponded roughly with the area behind Gerdy's tubercle, described by the French anatomists.

On the basis of this localization of pain, a tentative diagnosis of a sprain fracture was made and an x-ray was ordered. This was reported by Dr. Pomeranz as showing a small oval shadow which was situated just beneath the tender area and probably represented a sprain fracture with incomplete separation of the fragments (Fig. 1.) In view of the fact that the symptoms were subsiding, no treatment was considered necessary.

CASE 2.* C. S., a male, aged sixty-five, was admitted to the Hospital in June 1928. He had been struck by an automobile while crossing the street two days previously and was unable to rise or to walk on the affected left limb.

On admission to the Hospital, there was marked tenderness over the external condyle of the left tibia with moderate effusion into the knee joint. There was no lateral instability and no anteroposterior mobility.

FIG. 3

Anteroposterior view, showing small fragment detached from the tibial surface. The head of the fibula is normal.

The x-ray reported by Dr. Pomeranz showed a complete longitudinal fracture of the external condyle of the tibia at its outer aspect, involving the joint. There was a separation of a small shell-like fragment of bone, as well as an incomplete oblique fracture at the base of the posterior crucial spine, with separation of the fragments.

The following day the knee joint was aspirated and forty cubic centimeters of bloody fluid, containing free fat globules, was aspirated, and a posterior plaster-of-Paris splint was applied. One week later, a plaster-of-Paris bandage was applied with the knee in 175 degrees of extension. Following removal of the cast, the patient made an uneventful recovery.

CASE 3. R. G., a male, aged twenty-five, was seen on May 1, 1935. He had fallen on his flexed right knee some four days previously. There was a history of an injury to the same knee received some years ago while playing football. Although there had been occasional attacks of locking, the knee apparently had caused no recent symptoms.

On examination, the knee was found to be markedly swollen. Extension was limited to 160 degrees; flexion, to 90 degrees. There was a marked degree of anteroposterior and lateral mobility, especially on abduction. Pressure over the femoral attachment of the tibial collateral ligament elicited tenderness. In addition, there was marked tenderness over the external tibial condyle just above and medial to the head of the fibula.

X-ray of this area (Fig. 3) showed a characteristic cortical fracture of the external condyle of the tibia. It was apparent, however, that this injury was of minor importance in comparison with the other injuries to the ligaments of the knee joint.

At operation, the anterior crucial ligament was found to be torn just above its tibial attachment, and was resected. The internal semilunar cartilage was found to be detached from the tibia, and this, too, was excised. The joint was closed. The tibial collateral ligament was then exposed extra-articularly and a long transverse tear in its femoral attachment was sutured and reenforced by overlapping. A plaster-of-Paris bandage was applied. Uneventful convalescence followed.

*The author is indebted to Dr. H. Sonnenschein for the privilege of reviewing this case.

Each of these patients gave a history of injury with the knee in flexion. In the first case, that of an incomplete fracture, there was localized tenderness, a suggestive roentgenogram, and a transitory interference with function. In the second case, in addition to these symptoms, there was a marked hemorrhagic effusion into the joint. In spite of this, there was no evidence of any lateral hypermobility. In the third case, there was increased lateral mobility, but this was attributed to the presence of the other ligamentous lesions rather than to the cortical fracture. That this was the case is evidenced by the fact that the lateral instability disappeared promptly upon suture of the tibial collateral ligament.

The presence or absence of lateral hypermobility appears to be an important point in the differential diagnosis of cortical fractures. Thus, a fracture of the tibial condyle or a sprain fracture of the head of the fibula might give essentially the same clinical picture of injury to the flexed knee as does cortical fracture of the tibial condyle, and might result in localized tenderness with or without effusion. Apart from the roentgenogram, the presence of abnormal lateral mobility on adduction would suggest the former of these two conditions, while its absence would tend to support the diagnosis of cortical fracture. This is the more significant when it is realized that the roentgenographic appearances of sprain fracture of the head of the fibula and cortical fracture of the tibial condyle may be quite similar, as the following case demonstrates.

FIG. 4

Anteroposterior view, showing marked similarity to Figure 3. It is to be noted that there is a definite irregular concavity in the head of the fibula. Clinically, the patient presented signs of preternatural adductibility of the leg on the femur.

CASE 4. D. D., a female, aged twenty-eight, was seen in the Out-Patient Department four weeks after an automobile injury. There was marked tenderness on pressure over the lateral condyle of the tibia. There was some limitation of flexion and extension, but the striking point in the clinical picture was that the leg could be abducted on the femur beyond the normal range. On the basis of this finding, a diagnosis of fracture of the head of the fibula, or of the external tibial condyle, was tentatively made. X-ray showed a chip fracture of the head of the fibula with slight separation of the fragments (Fig. 4).

If Figure 4 be compared with Figure 3, great similarity will be noted, and only careful study will demonstrate the fact that the free fragment of bone is derived from a small concavity in the head of the fibula.

In evaluating the roentgenographic evidence of this type of cortical fracture, the position of the leg is of the utmost importance. In Figure

FIG. 5-A

Photograph of a tibia in which the area of avulsion fracture is shown in dark ink.

FIG. 5-B

Shows the same area rotated so that in profile it appears to lie over the head of the fibula. This is the best means of separating the shadow cast by the fracture from that due to the tibia. In roentgenography, the tube should be directed anteriorly and medially sufficiently to project the shadow of the tender area beyond the head of the fibula.

5-A, the area which is customarily avulsed is shown by the dark shadow. It will be noted that, unless there is marked separation of the fragments, the shadow cast by the fractured area must be superimposed upon the shadow cast by the outer half of the tibial condyle and thus be rendered inconspicuous. In order that the shadow may be thrown away from that of the tibial condyle, the exposure must be oblique, as was attempted in Figure 1. On the other hand, when this is done, the fractured area seems to lie just above the fibular head (Fig. 5-B), and the conclusion may be drawn that the fragment is derived from the head of the fibula rather than from the lateral aspect of the external tibial condyle.

In reviewing the literature, the author could find no clinical information on this interesting lesion. By accident, a reference to the experimental work of Segond was noted. Though no clinical cases are cited in this work, it appears that, in studying the effects of rotation, Segond accurately described the pathology of the type of cortical avulsion fracture which has been mentioned. Briefly summarized, the conclusions to which Segond came as a result of his experimental work are as follows:

Neither external nor internal rotation can take place with the knee in

extension. With the knee in this position, rotation is converted into forced abduction or adduction and results in the usual type of injury to the crucial and collateral ligaments of the knee joint. With the knee flexed to 145 degrees, either internal or external rotation can take place. If the knee is rotated internally, tension is noted in the lateral and crucial ligaments, but the site of maximum tension is at a point beyond and behind Gerdy's tubercle, where the articular capsule is reenforced by the insertion of the femoral aponeurosis. At this point, there is found "a pearly, fibrous, resistant band of tissue which in all motions of internal rotation undergoes a marked degree of tension".

This is the area of the external tuberosity shown by the dark shading in Figure 5-A. It is described by Rouvière as presenting: (1) posteriorly and externally, an articular facet, smooth, rounded, facing downward,

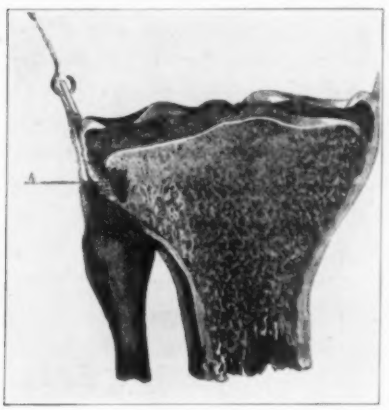

FIG. 6-A

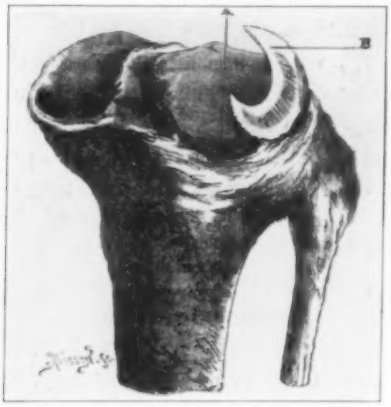

FIG. 6-B

Original drawings from Segond's article, showing the pathological site of the fracture and its relation to the edge of the external semilunar cartilage. (*Reproduced by courtesy of Le Progrès Médical.*)

backward and outward—the peroneal facet for the articulation with the head of the fibula; (2) in front and externally, the tubercle of Gerdy; (3) in front and below, an oblique crest extending from the tubercle of Gerdy to the external border of the tibial tuberosity and, with the tubercle of Gerdy, affording insertion to the tibialis anticus and the tensor fasciae femoris muscles. Lewis, in Gray's Anatomy, describes this area as follows: "Its lateral surface is convex, rough, and prominent in front; on it is an eminence, situated on the upper border of the tuberosity and at the junction of its anterior and lateral surfaces, for the attachment of the iliotibial band."

As a consequence of the marked tension on this "pearly band" of resistant tissue (the insertion of the iliotibial band), the site of insertion tears out. In thirty-eight experiments, Segond was able to produce the lesion seventeen times. In fourteen instances, the tear was complete and in the others, incomplete. He pointed out that in the milder cases, as in

Case 1 described in this paper, the lesion might exist by itself without having caused an opening into the joint. In the more complicated cases, it might be associated with tearing of the synovial membrane and injuries to the other ligamentous structures of the knee, as in the author's Cases 2 and 3. The lesion is remarkably constant in site and appearance. It usually consists of a small cavern in the spongy tissue of the external condyle of the tibia. This cavern varies in depth from five to ten millimeters. It usually communicates with the interior of the knee joint by a small slit like a buttonhole, which is hidden beneath the anterior edge of the external semilunar cartilage (Fig. 6). When the lesion is very small, it may not communicate with the joint. When the fracture is severe it never extends anteriorly beyond the tibial tubercle or posteriorly beyond the tibiofibular articulation.

This avulsion is caused by tension on the iliotibial band at its insertion into the area behind Gerdy's tubercle. It is usually acquired by injury, with the knee in the partly flexed position, but it may also be produced with the knee in the fully flexed position, if the heel is held medially to the axis of the femur during the internal rotation of the leg. Apart from the mechanism of its production, the characteristic features of the condition are the localization of the tenderness, the sudden development of a traumatic hemarthrosis, and the characteristic roentgenographic appearance. In discussing the question of the hemorrhagic effusion into the joint, Segond quoted Ficatier, who first pointed out the significance of the fat in sprains of the knee. Like Kling, who discussed this matter later, Ficatier was of the opinion that fat found in repeated aspirations from a knee joint indicated quite certainly the presence of an intra-articular fracture.

The treatment of the condition is symptomatic. If necessary, the effusion should be aspirated repeatedly. The leg may be put at rest either in a cast or on a posterior splint, if the separation of the fragments is sufficient. If no separation of the fragments has occurred, simple rest or strapping of the area is sufficient. Physiotherapy is indicated.

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TUNICA VAGINALIS IN ARTHROPLASTY OF SMALL JOINTS*

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Since synovial membrane is the normal lining of a joint cavity except where cartilage exists, it appears that in reconstructing a joint cavity the membrane used should be histologically as nearly identical with the synovia as possible. Tunica vaginalis resembles the synovia histologically and also functionally in its ability to secrete a fluid, and the author believes it should be used more generally in preference to other tissues now commonly employed. Such use of the tunica vaginalis is not original. Flaps taken from hydroceles and peritoneum from hernia sacs have been employed many times previously.

Before using tunica vaginalis in arthroplasty in human beings, it was used experimentally in eight dogs for reconstruction of the knee joint and for producing a pseudarthrosis in the leg. Five of these dogs were followed for a period of four months. The joints were examined *post mortem*, and, in all, the tunica vaginalis was found to form a thin membrane over the end of the bone. In the cases of pseudarthrosis, the membrane was placed over one end of the cut bone, the other cut end being left uncovered. In each case, no effort was made to prevent the dog from bearing weight on the leg. At the end of four months, the new joint cavity was found to contain a moderate amount of clear straw-colored fluid which was sterile. The end of the bone on which the tunica vaginalis had been placed was round and smooth and covered with a membrane resembling synovia. The other end of the bone, not originally covered with a membrane, had been thrown out in a roughened, irregular formation. It had not yet become overlaid with a fibrous covering, as is supposed to be the case in arthroplasty without the use of some soft-tissue transplant.

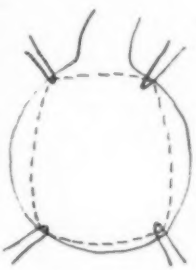

FIG. 1

Four sutures are placed in the tunica vaginalis before it is removed from the testicle in order to aid in placing it in the new field without trauma from forceps.

When fascia lata or other tissue is used, the interposed tissue loses its specific characteristics and is transformed into a tissue which, in part, forms the new capsule and, in part, the lining membrane of the joint capsule and the bony surface. This layer of interposed tissue, while transformed into a fibrous covering of the bone, never attains a degree of differentiation as does the living cartilage or synovia, although functionally it appears to replace it fairly satisfactorily.

* The experimental work described in this paper was done at the University of Maryland School of Medicine and College of Physicians and Surgeons.

If the interposed tissue is to resemble the synovial lining of a normal joint, it should have a structure and function similar to the synovial membrane. The normal synovial membrane is a special structure, the function of which is to produce a lubricating fluid. As has been stated, the tunica vaginalis resembles the synovial membrane histologically, as well as functionally in its ability to secrete fluid. Unfortunately, it is available as an autogenous transplant only in the male. It is also limited in amount, so that it can be used only for the hip joint and the smaller joints of the body. In the case of a normal tibiofemoral articulation, when the patella is ankylosed to the femur, a free transplant of tunica vaginalis will give a covering for the raw bony surface which closely resembles the normal synovia present in the knee joint. In the jaw, wrist, metacarpal and phalangeal joints, this material is satisfactory as its thinness and elasticity make it easy to suture. If four sutures are placed in the tunica vaginalis before it is excised, it can be handled with more ease and less trauma and can be placed easily in its new field. For the larger joints such as the knee, fascia lata is more suitable, because it can be obtained in sufficient quantities to cover the entire denuded surfaces.

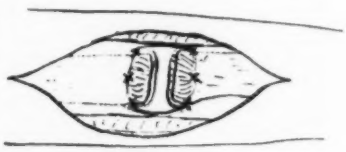

FIG. 2

Diagram illustrating arthroplasty of the phalangeal joint through lateral incisions, in which tunica vaginalis is used as a covering for the reconstructed joint surfaces.

FIG. 3

Covering of reconstructed head of the femur with tunica vaginalis in arthroplasty of the hip.

Since 1929, the author has used tunica vaginalis clinically in a limited number of cases.

CASE REPORTS

CASE 1. A young colored man, thirty-two years of age, came to the hospital with ankylosis of both hips of some years' standing, secondary to an infective arthritis. The arthritis was apparently quiescent and had shown no activity for over a year.

An arthroplasty of the right hip joint was done. The fibrocartilage over the head of the femur was removed and also the fibrocartilage covering the acetabulum. After the hip joint had been prepared for the transplant, an incision was made in the inguinal region just below the external inguinal ring and the testicle was made to present through this incision. The tunica vaginalis was distended with saline until it was about three times its normal size. It was then excised, slipped over the reconstructed head of the femur, and held in place with catgut sutures. The thin tunica vaginalis fitted snugly over the reformed bone without wrinkling. The inner secreting layer of the tunica vaginalis was placed to form the joint cavity, the fibrous layer being next to the denuded bone. The acetabulum was left uncovered. The right leg was placed in traction to prevent the new joint surfaces from coming in contact, and motion was started on the third day after operation.

The results were only fair. Motion of approximately 75 degrees was obtained, which allowed the patient to walk about, although the joint was not entirely painless.

CASE 2. A man, forty-three years of age, came to the hospital with an old compound fracture of the distal end of the radius. The displaced head had dislocated posteriorly and had healed in a position which prevented dorsiflexion of the wrist.

The distal end of the displaced radius was excised and the denuded area was covered with tunica vaginalis. Healing progressed satisfactorily. Motion of the wrist was limited by approximately 20 degrees, apparently due to adhesions about the wrist joint at the time of the original compound fracture.

CASE 3. A man, twenty-eight years of age, suffered from fibrous ankylosis of the second metacarpophalangeal joint of the right hand, following fracture of the distal end of the metacarpal bone.

The head of the metacarpal bone was excised, leaving a concave surface as is done in the tibia in reconstructing the knee joint. A piece of tunica vaginalis was placed over the end of the denuded metacarpal bone. The hand was placed in a banjo splint with the finger in traction. On the third day after the operation, motion was started with traction in place to prevent recurrence of adhesions between the tendons and the periarticular tissues.

Recovery was satisfactory, with a range of motion from full extension to 60 degrees of flexion. This is approximately 30 degrees less than the joint can normally be flexed.

CASE 4. A man, forty-six years of age, had received a fracture-dislocation of the proximal head of the right radius. As a result of this fracture, there was a proliferation of new bone anteriorly which not only limited supination of the forearm, but flexion and extension of the elbow as well.

Through the usual incision, the fractured dislocated head of the radius, together with the new bone about the area, was removed as cleanly as possible. The raw surface was covered with a piece of tunica vaginalis.

Recovery was uneventful. Motion was started the fifth day after operation. Motion progressed satisfactorily with approximately 10 per

FIG. 4

Pseudarthrosis in a dog's leg four months after the distal end of the bone was covered with tunica vaginalis. The proximal end (*1*) was not covered and irregular growth of bone occurred. The end covered with tunica vaginalis (*2*) was smooth and protected with a thin, shiny, moist membrane resembling synovia. The new joint surface contained a small amount of sterile fluid resembling synovial fluid.

cent. permanent limitation of supination. There was no limited motion of the elbow joint, and movements were painless.

CASE 5. The patient was a man, twenty-three years of age, with ankylosis of the second metacarpophalangeal joint which followed a crushing fracture of the proximal phalanx of the finger.

An arthrotomy was done and the cartilage was removed from both the metatarsal head and the proximal end of the first phalanx. The area was covered by a flap of tunica vaginalis. The graft covered both the raw surface of the metacarpal bone and the phalanx. The finger was placed in traction and motion was started the fifth day after operation.

This treatment resulted in 60 degrees of flexion, but some lateral instability of the joint.

CASE 6. A man, forty-eight years old, sustained a fracture of the proximal end of the radius with anterior displacement of the head. He refused operation at the time of injury, but later, because of the limited painful motion of the elbow joint, submitted to operation. At that time, there was little supination and only about 40 degrees of motion in the elbow joint. The dislocated head of the radius was removed, together with the newly formed bone about that area. The end of the radius was covered with a graft of tunica vaginalis.

Recovery was satisfactory. There was slight residual loss of supination. Movements of the elbow joint returned to normal and were painless.

SUMMARY

Experimentally in dogs and clinically in human beings, tunica vaginalis has been found to be a suitable membrane for covering raw surfaces in arthroplasty of the smaller joints.

The secreting surface of the tunica vaginalis is turned toward the joint cavity and the fibrous elastic layer is placed against the denuded bone surface.

It is believed that, in male patients, the tunica vaginalis is the most satisfactory interposing membrane which can be used in arthroplasty of the small joints.

SURGICAL MANAGEMENT OF PES CALCANEUS *

BY O. L. MILLER, M.D., CHARLOTTE, NORTH CAROLINA

The degree of deformity present in paralytic calcaneus is dependent upon the extent of muscle imbalance at the ankle. Recovery after infantile paralysis may leave the posterior group of leg muscles only slightly weaker than the anterior group, with moderate imbalance and mild calcaneus. On the other hand, the posterior group of leg muscles may be completely paralyzed, resulting in extreme calcaneocavus, marked imbalance, and frank heel-walking. There may also occur weakness or complete paralysis of the inner or outer lateral group of muscles at the ankle, in addition to the involvement of the posterior group, with resultant calcaneovalgus or calcaneovarus. It is fortunate that certain muscles whose tendons pass about the ankle are frequently not involved in the paralytic distribution and are available for transplantation into the defective tendo achillis in a foot with calcaneus deformity.

In doing a foot-stabilization operation for correction of calcaneous deformity, substantial sections of bone must be removed from the upper surface of the os calcis and the lower surface of the astragalus. Successful correction of this deformity depends upon ample resection of these masses of bone, so that the architecture of the foot will be entirely changed in its relation to future weight-bearing. The neck of the astragalus should be sectioned and the head should be removed, so that it and the opposing scaphoid may be thoroughly denuded of cartilage. The calcaneocuboid joint should be resected and the planter fascia should be sectioned. As the wound is closed, the head of the astragalus is put back in its bed or placed laterally or medially to its former position, depending upon whether varus or valgus of the forefoot is to be corrected. When the operation is completed, the entire foot should be shifted backward and upward on the astragalus. The extremity is then dressed in plaster with the foot in moderate equinus and the knee slightly flexed. In this position, recovery of any latent power existing in the gastrocnemius, soleus, or other retromalleolar muscles is encouraged. While the plaster cast is setting, firm pressure should be applied to the sole of the foot in order to stretch the plantar structures as much as possible.

In mild deformities, a calcaneus type of foot-stabilization operation may be all that is necessary to effect satisfactory balance, but, in the more severe types, both stabilization and tendon transplantation are indicated. The principal tendons available for transplantation to reenforce the Achilles tendon, in order of value and availability, are: the peroneals, the posterior tibial, the anterior tibial, and the long toe extensors.

Five weeks after the stabilization operation has been performed, the

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

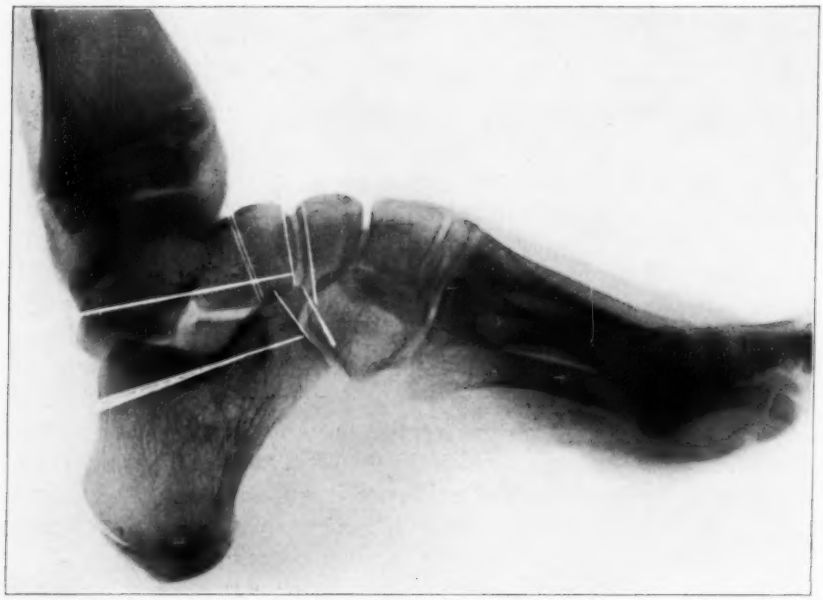

FIG. 1

Illustrating the substantial wedges of bone to be removed from the opposing surfaces of the bodies of the os calcis and astragalus in the correction of calcaneus deformity.

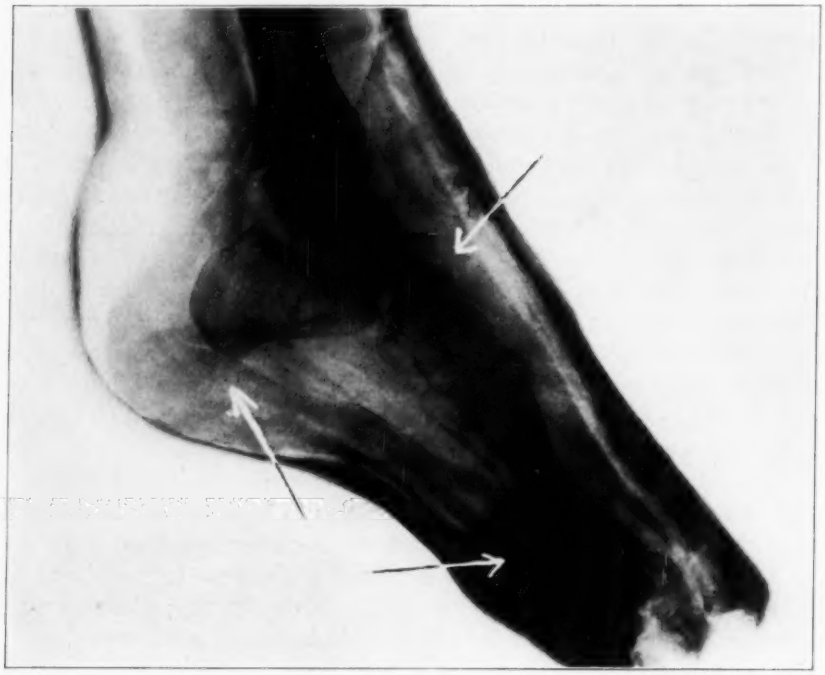

FIG. 2

Position in which the foot should be dressed following a calcaneus type of foot stabilization. The same position should also be used after manipulation.

FIG. 3

Illustrating the improved relations of the bones of the foot after a calcaneus type of foot stabilization.

FIG. 4

Posture of foot five years after a calcaneovarus type of stabilization and transplantation of the tibialis posterior tendon into the tendo achillis.

cast should be removed for a refining manipulation of the foot. After manipulation, another snug cast should be applied to the leg. Firm pressure should be exerted on the sole of the foot as before, thrusting the os calcis upward and backward. With the addition of a plaster-heel extension to the cast, the patient may be allowed weight-bearing after manipulation, since the forces so expended will be corrective.

Postoperative massage and physiotherapy should be instituted seven weeks after operation, and weight-bearing in a high shoe should be permitted about two weeks later. If the heel of the shoe is broadened at its base and slightly raised, it will serve as a protection to the foot in its new position and will improve the gait. As pointed out by Hoke in his early work on stabilization of paralytic feet, the criterion of a successful surgical result is a foot that looks natural in a shoe and is stable when the patient is standing or walking. Such a foot should not require a brace.

The observations in this paper are based on experience with seventy-five foot-stabilization operations for calcaneus deformity. The feet were classified as: mild calcaneus, thirteen; calcaneocavus and valgus, fifty-three; calcaneovarus, nine. The average age of these patients at operation was eleven years. Tendon transplantation supplemented the foot stabilization in thirty-seven cases. The peroneus longus and peroneus brevis tendons were transplanted into the tendo achillis in twenty-eight cases; the peroneus longus and the tibialis posterior tendons, in three; the peroneus longus and the tibialis anterior tendons, in two; the tibialis anterior and the extensor digitorum longus tendons, in two; the tibialis anterior tendon, in one; and the tibialis posterior tendon, in one.

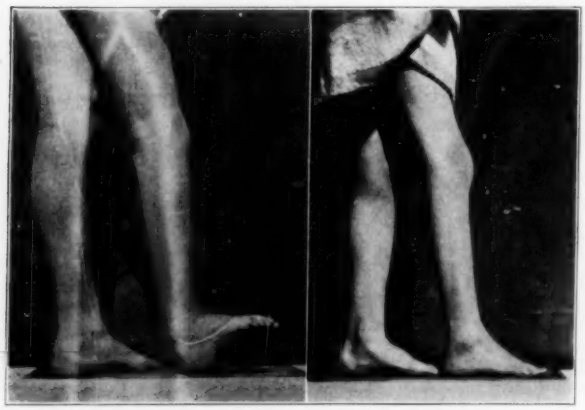

FIG. 5-A FIG. 5-B

Fig. 5-A. Appearance of foot before operation.
Fig. 5-B. After stabilization operation.

SUMMARY

A reasonably successful result attending the surgical management of calcaneus deformity depends upon: (1) accurate evaluation of the bony and muscular pathology; (2) the correction of overgrowth and disturbed relations in the depth of the os calcis and astragalus by a calcaneus type of foot stabilization; (3) the dressing of the foot in an overcorrected position after operation and after manipulation; (4) the best possible balancing of muscle pull where tendon transplantation is indicated; and (5) careful direction of early weight-bearing in properly built shoes.

THE TREATMENT OF CLUB FEET *

BY LLOYD T. BROWN, M.D., BOSTON, MASSACHUSETTS

The following method of treatment of congenital club feet has made it possible to get useful feet and legs without the use of forcible manipulation, ether, tenotomies, repeated plaster casts, or adhesive-plaster strapping to the whole foot and leg. Naturally the earlier the treatment is begun the better.

It is well known that continuous traction will gradually tire out a muscle; that a contracted muscle put on the stretch will gradually lengthen; and that a stretched muscle, if relaxed, will shorten so that it can get back to a position in which contraction can occur. These principles can be applied to the problem of club feet in the following manner.

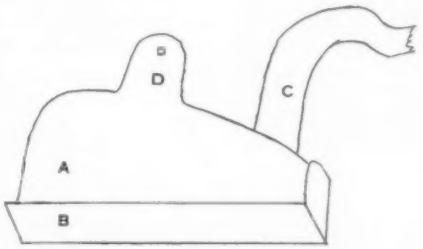

FIG. 1-A

Aluminum foot plate as seen from above.
A: Sole plate.
B: Inner border of sole plate turned up at a right angle.
C: One-half-inch binding tape, at least three feet long, fastened to sole plate.
D: Projection or outrigger attached to the outer side of sole plate to which is attached the elastic traction.

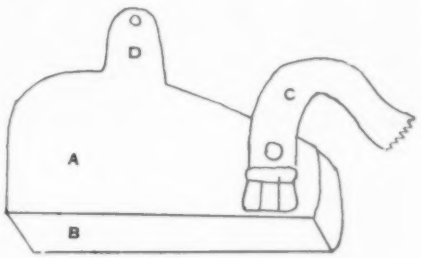

FIG. 1-B

Aluminum foot plate as seen from below. Note the buckle at the sole-plate end of the tape.

For the very young—a few days to a few weeks old—an aluminum foot plate (Figs. 1-A and 1-B) is made a little longer than the foot and the same width. The inner border of this plate is turned up at a right angle to the sole so that it is just higher than the dorsum of the great toe joint; this upturned border is carried around behind the heel. To the sole plate at the posterior end is attached a piece of soft binding tape, one half an inch in width and at least three feet in length. On the outer side of the sole plate is a projection to which can be applied the elastic bands for traction. The foot is placed on the sole plate and bound to it without any attempt to get correction. The important point is to get the heel and the foot firmly attached to the plate. The binding tape should cover the whole foot with a figure-of-8 around the ankle.

To the anterior outer side of the thigh, just above the knee joint, is applied a small piece of adhesive plaster, two by two inches; the exact

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

Case 1. Male, aged five years, with bilateral club-foot. In spite of much treatment with adhesive and plaster casts, there had been several recurrences. The patient was seen in April 1934, because lengthening of the Achilles tendon had been advised, with possible arthrodesis of the subtalar joint.

FIG. 2-A

Fig. 2-A: Posterior view, April 9, 1934.

Fig. 2-B: Lateral view, April 9, 1934. Note position of the os calcis and the heel cords; the heels do not come to the ground. Note the knock-knee. The patient walks on his toes and turns the feet in, particularly the right foot. Otherwise, the feet are very limber and easily overcorrected.

The right foot cannot be flexed within 25 degrees of a right angle and the left, within 20 degrees.

The patient was fitted to plaster-of-Paris night shoes with the feet in the best corrected position, and elastics were added to the day shoes.

FIG. 2-B

FIG. 2-C

FIG. 2-D

FIG. 2-E

FIG. 2-F

Fig. 2-C: Posterior view, June 28, 1934. Note position of heels.

Fig. 2-D: Lateral view, June 28, 1934. Note the amount of dorsiflexion possible with no back-knee deformity.

Fig. 2-E: Anterior view, June 28, 1934.

Fig. 2-F: Posterior view with weight, December 12, 1934. Note overcorrection of the os calcis.

Fig. 2-G: Lateral view without weight, December 12, 1934. Note possible correction of equinus.

FIG. 2-G

position and size are chosen with reference to the amount and the direction of the traction desired. Traction is made between the sole plate and the adhesive plaster on the thigh with only two small rubber bands such as come around checks. It is *continuous* day and night, being removed only for bathing, gentle manipulation by the mother, and changing the adhesive plaster. The use of adhesive plaster can be kept up for months without skin irritation by changing its position on the thighs from time to time.

It is interesting to note that, when traction is applied, the stronger muscles usually begin to work, but, every time they relax, the foot is pulled into a more correct position so that there is a continuous slight corrective force being applied. For this reason, it is not necessary to use more than two elastic bands.

With a larger foot, the same type of traction can be applied by means of a plate attached to the sole of a shoe. The shoe should be laced and should be a half inch to an inch longer than the foot and the same

FIG. 3-A

Case 2. Male, aged four days, with bilateral club-foot. Neither foot could be corrected.

Fig. 3-A: Photograph, February 24, 1928.

Fig. 3-B: Anterior view, May 21, 1934.

Fig. 3-C: Posterior view, May 21, 1934.

Note size and shape of the lower legs, the line of the Achilles tendons, and the shape of the feet.

The treatment consisted of an aluminum splint with elastic traction day and night, until overcorrection was obtained. Then a shoe was worn with the elastic traction day and night for two years, until the child was walking. This shoe was then worn only at night. If there is any tendency to recurrence in such a case, the night traction should be kept up for several more years.

FIG. 3-B

FIG. 3-C

FIG. 4-A

Case 3. Male, aged two weeks. Bilateral congenital club-foot with marked adduction and equinus; practically no heel and very tight heel cords. Both feet were so rigid that no more than one-half correction was possible.

Fig. 4-A: Before treatment, October 31, 1934.

Fig. 4-B: Photograph taken in December, 1934, showing splints applied with elastics to thigh.

Fig. 4-C: Photograph, January 23, 1935, showing application of elastic traction with shoes. This traction can be used when correction of the deformity has been obtained.

FIG. 4-B

FIG. 4-C

FIG. 5-A

Case 4. Male, aged three months, with unilateral club-foot (right). The twin brother of this child had no deformity.

Fig. 5-A: Photograph, January 12, 1931. The varus cannot be corrected and the foot is rather stiff.

Fig. 5-B and Fig. 5-C: Photographs, March 23, 1931, showing shoe and elastic traction.

Fig. 5-D: Photograph, May 23, 1934, three years later. Note the size and shape of the foot and the lower leg.

FIG. 5-B

FIG. 5-C

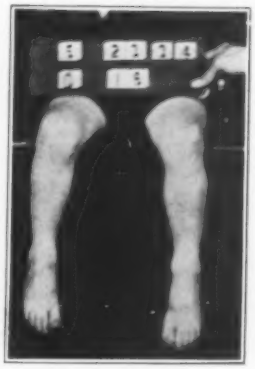

FIG. 5-D

width as the foot. This traction should also be continuous, day and night.

In older children, the continuous traction can be replaced at night by a bivalved plaster cast from toes to just below the knee. The night protection, whether it be with a cast or with the traction apparatus, is of the greatest importance and should be used for a long time,—several years if there is any tendency to recurrence, as is so common during the growing period. The day traction does not need to be used after full correction of the deformities has been obtained.

SUMMARY

It has been found possible and simple to obtain marked overcorrection of all the deformities of club feet by the use of continuous slight traction by means of elastic bands. Since this method has been followed, it has not been necessary, in children up to the age of five years, to use forcible manipulations, ether, tenotomies, or stretching by frequently changed plaster casts or adhesive plaster.

USE OF FASCIA LATA TO STABILIZE THE KNEE IN CASES OF RUPTURED CRUCIAL LIGAMENTS

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NEW YORK, N. Y.

In severe lacerations of the knee, the usual finding is rupture of both crucial ligaments and one of the two collateral ligaments. Both collateral ligaments are rarely ruptured, as the force causing the injury is generally from the side and the knee is straight. The medial ligament is usually the one that is injured. Several methods of repairing the crucial ligaments have been advocated.

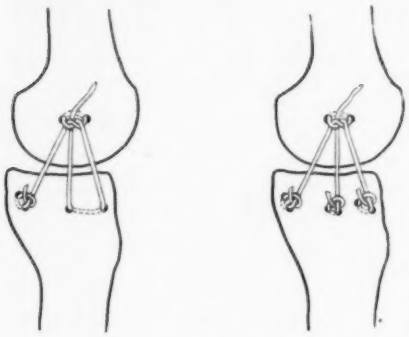

FIG. 1

The authors' method of repair of the medial collateral ligament.

In a case of rupture of both crucial ligaments and the medial collateral ligament of the knee, repair of the medial collateral ligament alone was done by the authors, as shown in Figure 1. It was thought at the time that repair in this fashion might obviate the need for reconstruction of the crucial ligaments. This was later found to be the case, apparently due to the fact that the anterior strand of fascia lata limits the forward slipping of the tibia and the posterior strand stops the posterior displacement.

A review of the literature shows numerous methods of repairing the collateral ligament, but rarely is mention made of stabilization of the knee and ruptured crucial ligaments by the repair of the collateral ligaments. Bennett plicated the collateral ligament with fascia lata; Bost, Edwards, and McMurray used nearby tendons; and Wilson turned down a fascial flap. Cotton and Morrison in 1934 advocated a cross-shaped method of repair. (See Figure 2.) Their procedure most nearly approximates the authors' method, which follows:

FIG. 2

The cross-shaped method of repair advocated by Cotton and Morrison. (*Reproduced through the courtesy of The New England Journal of Medicine.*)

A full-length exposure of the lateral aspect of the fascia lata is made and a heavy section is removed from the crest of the ilium to the knee joint. This strip is then implanted posteriorly in a tunnel in the tibia and tied, and the knot is sewed with silk. The free end is drawn through a tunnel located at the femoral epicondyle and a knot is tied, as shown in Figure 1. The end

is then passed backward through a tunnel in the anterior part of the tibial condyle to the point of original attachment of the collateral ligament, and thence upward to be tied and sewed with silk to the preceding knot at the femoral epicondyle. In case the external collateral ligament is being repaired, which is a rare condition, the attachment may be to the tibia and the head of the fibula.

A circular plaster splint should be applied from the groin to the ankle. This splint is worn for four weeks, subsequent weight-bearing and physiotherapy being carried out as indicated by the progress of the patient.

This procedure has been used in three recent cases,—two of rupture of the crucial ligaments and medial collateral ligament and one of rupture of the crucial ligament and the external collateral ligament. In all three cases, an attempt was made to repair the collateral ligament as well as to reenforce it with a few fascia-lata strands, but repair of the crucial ligaments was not attempted, as the damage to them was so severe that repair was not possible. In spite of the fact that the crucial ligaments were never repaired, all three knees were satisfactorily stabilized as far as lateral sway and anteroposterior displacement were concerned.

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STABILIZATION OF THE HIP BY THE TRANSPLANTATION OF THE ANTERIOR THIGH MUSCLES

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From the Hospital for the Ruptured and Crippled

The transplantation of the tensor fasciae femoris, sartorius, and straight head of the rectus femoris is suggested as a new method for stabilizing the hip in paralysis of the gluteus medius associated with weakness of the gluteus maximus, because it seems mechanically and physiologically more efficient than any of the existing operations. The mechanical advantages are: the increased strength of the transplant, the exertion of a diverse directional pull, and the increased support to the knee.

FIG. 1

Drawing demonstrating the origin and insertions of the muscles used as a transplant.

The increased strength of the transplant, in contrast to other procedures, is credited to the use of three good-sized muscles in place of the one muscle commonly employed. When joined, the tensor fasciae femoris, the sartorius, and the long head of the rectus femoris make a formidable transplant.

The diverse directional pull of these muscles is important, as it tends to hold the head of the femur in its proper position more efficiently. The tensor fasciae femoris is in the "line of straight pull". The rectus femoris and sartorius exert their pressure against the upper third of the femur and thereby prevent slipping of the femoral head. The increased knee support is of great consideration. The sartorius gives medial support and prevents "bending in" of the knee. The rectus femoris, by virtue of the quadriceps tendon, forms a strong anterior support, and the tensor fasciae femoris reenforces the knee laterally. Therefore, the combination of these muscles affords a good brace to this joint.

The physiological advantages lie in the contracting power that is invested in this conjoined group of muscles.

OPERATIVE TECHNIQUE

An incision is made, beginning at the posterior-inferior spine and following along the crest of the ilium to the anterior-superior spine. At this point the incision is brought downward and across the trochanter. The tensor fasciae femoris and sartorius are identified and removed from their origin along with some of the bony attachment. These muscles are freed as far as possible by blunt dissection. This procedure exposes the straight head of the rectus femoris, which is also detached and liberated as far as possible. The straight head of the rectus femoris is then sutured to the tensor fasciae femoris and sartorius; in this manner, quite a large mass of muscle is formed.

An area is prepared in the region of the inferior-posterior spine by cutting a small window in the ilium. The location for this window is ascertained by holding the extremity in extreme abduction and hyperextension and thereby determining the reach of the transplanted muscle. A tunnel is then made under the paralyzed gluteus medius and the anterior border of the gluteus maximus, and the transplant is carried through this tunnel while the limb is held in hyperextension and abduction. The conjoined muscles are fixed into the prepared space. After the wound has been closed in layers, a plaster spica is applied with the extremity in the position of hyperextension and abduction. The plaster is removed at the end of four to five weeks.

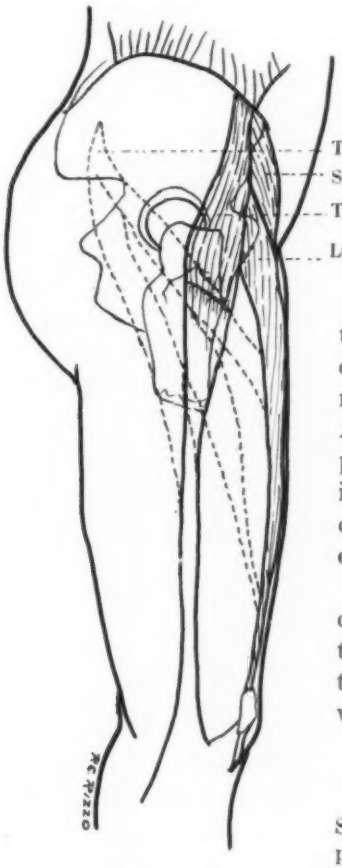

FIG. 2

Lateral view showing the directional change of the muscles used in the transplant.

This operation has been used in five cases with gratifying results. In each case the patient benefited by the operation; the typical gait resulting from gluteal paralysis was completely altered to one of security.

CASE REPORTS

M. H., a female, had had poliomyelitis in 1926. She had full power in the tensor fasciae femoris and partial power in the gluteus maximus. Her gait was peculiar and she walked with a marked limp. On April 21, 1932, the operation described was performed. The postoperative findings show that the buttocks have filled out, the swaying gait has dis-

appeared, and the patient is able to hyperextend the leg and also to abduct it against gravity. There is good external rotation, but internal rotation is not possible.

S. T., a male, had had poliomyelitis at the age of two years. There was slight power in the gluteus medius and the gluteus minimus. Other muscles about the hip were not functioning. A muscle-transplant operation was performed on April 15, 1932. The patient is now able to walk better and to hold the extremity in extension and hyperextension against gravity. The leg feels stronger, is more useful, and more stable.

A. M., a male, had had poliomyelitis at the age of seven and one-half years. There was a paralysis of the glutei and good power in the tensor fasciae femoris. His gait was poor. A transplant operation was performed on June 19, 1932. Both the patient and his family have noted considerable improvement in gait and attitude. There is good power of abduction and external rotation; internal rotation is absent. The patient is able to walk longer distances and to abduct and extend the leg against gravity.

R. W., a female, had had poliomyelitis at sixteen years of age. There was good power in the tensor fasciae femoris and the sartorius. The glutei were paralyzed and the patient was obliged to use a brace for support. A transplant operation was performed in November 1931. Since then, the limp has disappeared and the brace has been discarded. The hip is more stable and the patient is able to abduct and hyperextend the hip.

E. B., a female, had had poliomyelitis at the age of ten years. Normal power was present in the tensor fasciae femoris and the sartorius. The gluteus maximus was very weak and the gluteus medius was paralyzed. There was a marked swaying of the body in walking. A transplant was done November 14, 1934. At the last examination, six months later, the entire limb had developed considerably. The patient can abduct the limb against gravity and there is increased power in the gluteus maximus. Her gait shows remarkable improvement and she is able to discard her cane.

SUMMARY

The ideal case for this operation is the one in which the gluteus medius is paralyzed, the gluteus maximus is weak, and the muscles which comprise the transplant—the tensor fasciae femoris, the sartorius, and the rectus—are functioning normally. When these latter muscles are weak, however, great help is also derived from this operation.

Following the operation, the hip and knee are more stable and the swaying gait, which is very fatiguing and awkward, is lost.

The results obtained in the five cases in our series were gratifying.

DYSCHONDROPLASTIC BOW LEGS

BY DAVID SLOANE, M.D., MARIAN FRAUENTHAL SLOANE, M.D., AND AARON M. GOLD, M.D., NEW YORK, N. Y.

From the Hospital for Joint Diseases *

Dyschondroplasia [1, 6] is a retardation of the normal transformation of primordial cartilage into growing bone, which results in an irregular ossification at the epiphyseal-metaphyseal junction of the long bones. Ollier [5] coined the term and described the first case in 1899. The condition may involve isolated bones or extremities, or there may be a predominantly unilateral involvement of the extremities. Current usage designates the entire group as "dyschondroplasia" and limits the term "Ollier's disease" to the predominantly unilateral involvement of one side of the body [2, 3].

Within the past three years, we have encountered several cases of an unusual form of genu varum caused by a localized dyschondroplasia which was restricted to the inner half of the region of the upper tibial epiphysis. In two cases, the condition was bilateral; in one, unilateral. The patients were young girls ranging in age from four to seven years. In each case, the outstanding clinical feature was a marked degree of genu varum which became progressively worse as the child grew older. Roentgenograms showed similar changes in all three cases. A specimen for microscopic study was obtained in the second case.

FIG. 1

Case 1. D. D. Note the acute angle medially beneath the knees.

CASE REPORTS

CASE 1. D. D., a white girl, aged six, was admitted to the Hospital for Joint Diseases in November 1932. According to the mother, the child had developed a bowing deformity of the legs four years previously. This deformity had become progressively worse until it reached the stage shown in Figure 1.

The child's past history was essentially negative. She was born at full term and the delivery was normal. The child had been fed by bottle and had been given viosterol regularly. She began to walk at two years of age. The family history revealed no similar cases of deformity.

Examination showed marked lateral bowing of both legs, with a particularly sharp angulation at the upper

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FIG. 2

Case 1. D. D. Roentgenogram showing the compression, fragmentation, and medial spread of the upper tibial epiphyses and adjacent metaphyses.

FIG. 3

Case 2. N. C. Note similarity of this roentgenogram to Fig. 2. The condition is less marked here.

FIG. 4

Case 2. N. C. Note the same acute angulation beneath the knees as shown in Fig. 1.

inner ends of the tibiae. This condition was more pronounced on the right side than on the left. There was secondary bilateral pes valgus. When the patient walked, a marked laxity of the lateral ligaments of the knees made the heads of the fibulae appear prominent.

Roentgenograms (Fig. 2) revealed a sharp compression and fragmentation of the medial aspects of both upper tibial epiphyses. The underlying metaphyses were elongated and mushroomed medially so as to form large, bony masses.

CASE 2. N. C., a white girl, aged seven, was admitted to the Hospital for Joint Diseases in October 1934. The mother brought the child to the Hospital because of a bowing of the legs which had begun in infancy and which had become progressively worse. Figure 4 shows the appearance of the limbs upon admission.

The child was born at full term and the delivery was normal. The past history was irrelevant. Two sisters and two brothers were living and well. There was no history of familial diseases.

Examination revealed a marked lateral bowing of both legs, with an acute medial angulation beneath the upper ends of the tibiae. There was slight posterior bowing, with a resultant genu recurvatum. The femora showed some anterolateral bowing. The feet were secondarily pronated because of the lateral bowing.

The roentgenograms (Fig. 3) were similar to those in Case 1, but the condition was less marked. There was the same medial epiphyseal compression and fragmentation, with mushrooming of the metaphyses.

A biopsy specimen was obtained from the medial side of the left epiphyseal plate (Fig. 5). We are indebted to Dr. Henry L. Jaffe and Dr. Sheldon A. Jacobson of the Department of Pathology for the following description of the micropathology:

"The line of the epi-

FIG. 5

Case 2. N. C. Photomicrograph of section through the medial side of the upper epiphyseal plate of the left tibia. *A:* Epiphyseal cartilage. *B:* Metaphyseal bone. The arrows point out the irregular and poorly formed junction between the growing cartilage and the bone.

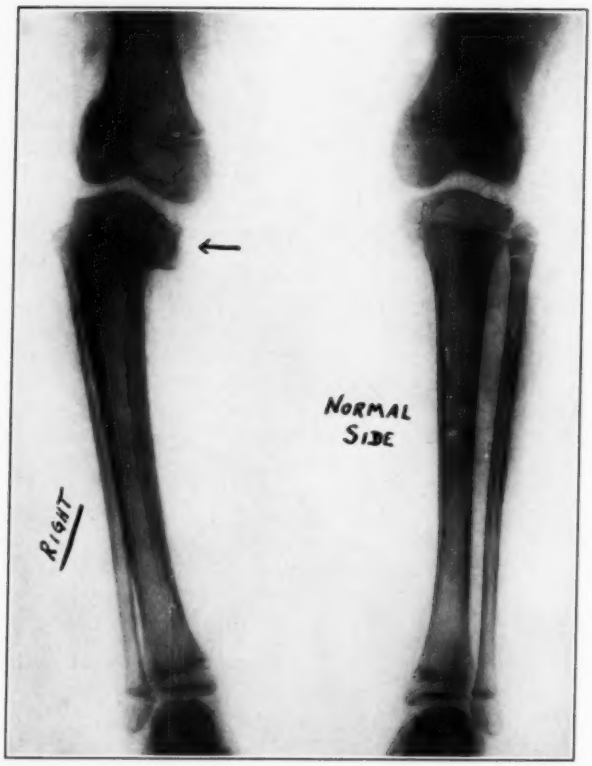

FIG. 6.

Case 3. A. G. Roentgenogram showing definite dyschondroplastic changes on the right side (note the arrow). The left side is normal.

physeal plate slopes sharply downward in the direction of the shaft. The epiphyseal cartilage in this region is rather pale-staining, particularly the nuclei. One gains the impression that the cells are either dead or dying. [This was cell death due to an acute inflammatory lesion which has no bearing on the dyschondroplasia.] They are somewhat more numerous and deep-staining in the part of the area adjacent to the bone. Nowhere, however, does the cartilage even remotely approach the normal epiphyseal architecture. There has been an extremely feeble attempt to group and line up some of the scattered nuclei. However, there is not even a suggestion of the well defined zone of clear cells that characterizes the normal epiphyseal plate, although a few of these clear cells may be seen. The reciprocal alignment of resorbing cartilage and growing bone trabeculae is also absent. In its place there is a very thin, irregularly demarcated zone of poorly calcified cartilage which penetrates in a most uneven fashion into a disorderly arrangement of shapeless bone trabeculae. Many, if not most, of the lacunae in this bone are devoid of nuclei. The marrow spaces show considerable fibrosis. The rows of active osteoblasts are not to be seen.

"Briefly, we have here a condition characterized by a failure of growth, differentiation, and ossification of cartilage cells. Even the 'resting' cartilage appears to be afflicted with a severe trophic disorder. We may interpret the above as a disorder of the dyschondroplastic group."

CASE 3. A. G., a white girl, aged four, was admitted to the Out-Patient Department of the Hospital for Joint Diseases in March 1935, with a history of increasing bowing of the right leg since birth. There were no similar cases in the family. Hospitalization for further study was refused. Examination showed a marked genu varum of the right leg, with a prominence along the inner side of the right knee. There was no limitation of knee motion.

Roentgenograms (Fig. 6) revealed medial compression, fragmentation, and mushrooming of the right upper tibial epiphysis and diaphysis. The left tibia was normal.

The cases cited naturally lead us to a consideration of the pathogenesis of the dyschondroplasias as a group. Murk Jansen[4] wrote an ex-

cellent treatise in which he considered normal bone development as the product of several interrelated processes. Any disturbance of this normal mechanism he termed "a dissociation of bone growth". The condition found in our cases may be considered as a localized form of bone dissociation, characterized by a retardation of the normal sequence of cartilage and bone development in the region of the upper tibial epiphysis.

SUMMARY

Dyschondroplasia is a retardation of the normal transformation of primordial cartilage into bone. In the three cases of dyschondroplastic bow legs presented, the process was limited to the region of the medial aspect of the upper tibial epiphysis. All of the patients were young girls in the first decade of life. In two of the cases, the condition was bilateral; in one, unilateral. A progressive and severe type of genu varum was the outstanding symptom. The roentgenograms showed typical changes in the region of the medial half of the upper tibial epiphysis. Microscopic section in the involved region of one of the patients showed a definite picture of dyschondroplasia.

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CONGENITAL ABSENCE OF THE MEDIAL SESAMOID BONE OF THE GREAT TOE

Report of Two Cases

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From The New York Orthopaedic Dispensary and Hospital

In all standard text-books of anatomy, and in the classical monographs of Pfitzner and Dwight, the two sesamoid bones at the metatarsophalangeal joint of the great toe are described as constant. In a recent extensive survey of the literature, the writer found reported no instance of the congenital absence of either of these sesamoid bones. Since the publication of that survey in 1933, only one paper dealing with the anatomy of the sesamoids has been published, and in this paper the invariable constancy of both sesamoid bones of the great toe is again affirmed.

Within the past year at the New York Orthopaedic Dispensary and Hospital, roentgenograms have been made of the feet of two patients showing congenital absence of the medial sesamoid bone. These patients were adults, one male and the other female, and neither came to the Dis-

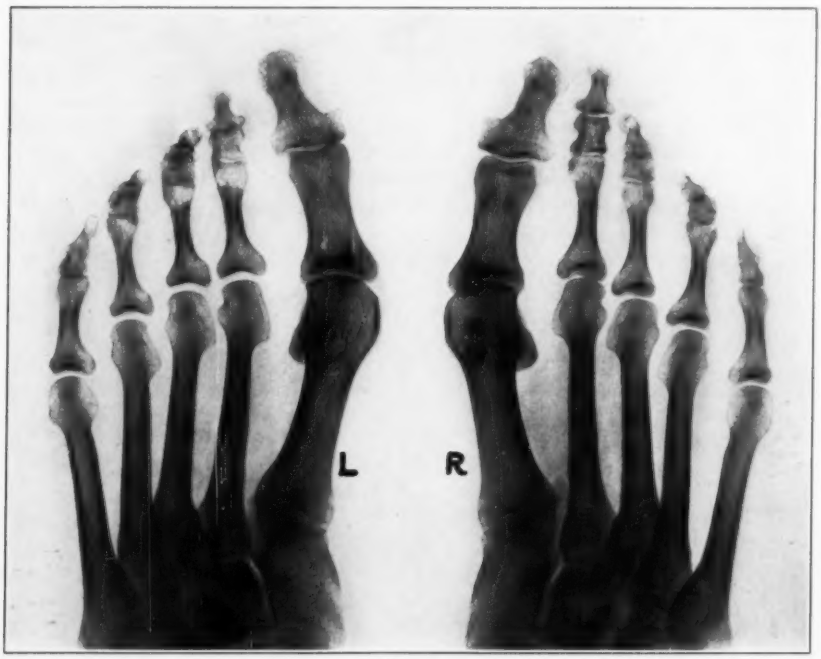

FIG. 1

Case No. 158,306. G. S., aged twenty-eight. Left medial sesamoid absent; right medial sesamoid small and bipartite. No symptoms referable to sesamoids.

pensary complaining of symptoms referable to the region of the sesamoid bones. Upon careful inquiry, it was ascertained that neither had ever had any complaint referable to these bones, and their claim that no opera-

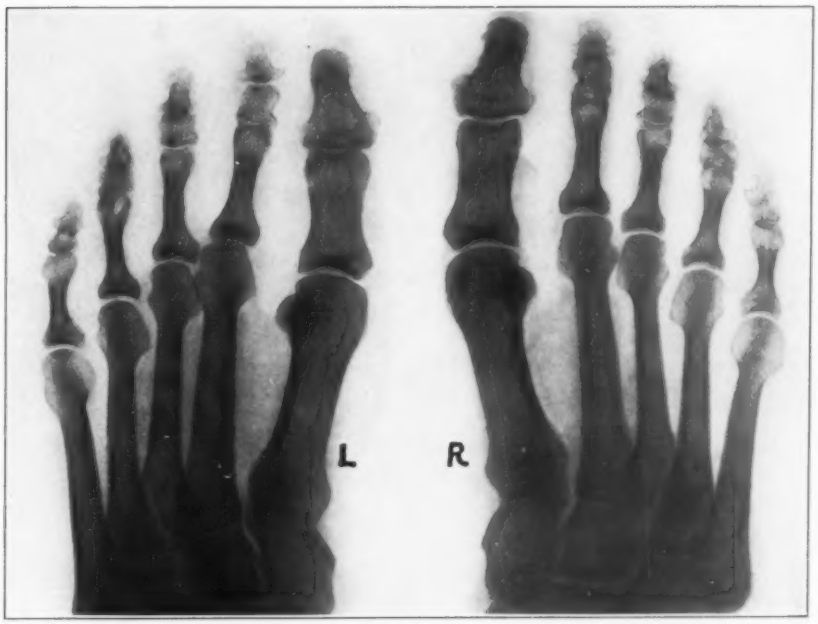

FIG. 2.

Case No. 181,922. J. C., aged thirty-three. Left medial sesamoid absent; right medial sesamoid rudimentary. No symptoms.

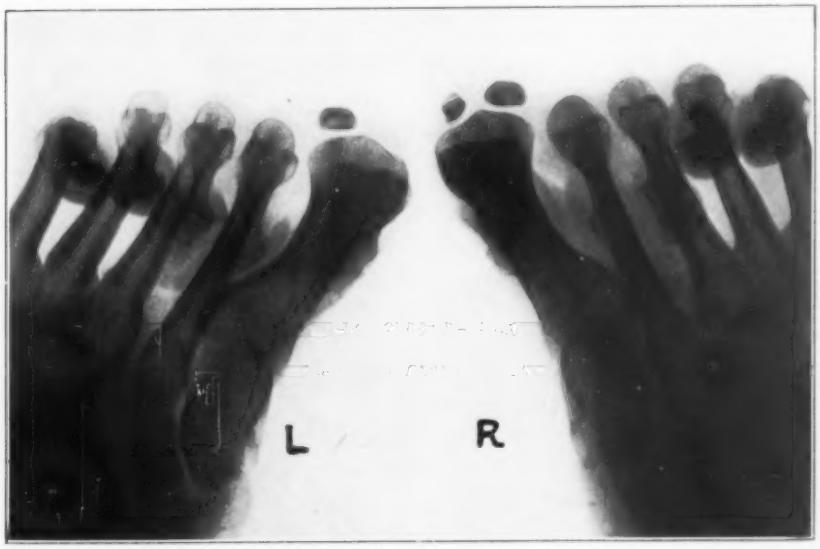

FIG. 3

Plantar view of feet of patient shown in Fig. 1.

FIG. 4

Plantar view of feet of patient shown in Fig. 2.

tion had ever been performed on the foot was substantiated by the absence of any surgical scar. In each patient, the left medial sesamoid was absent. Physical examination demonstrated no abnormal physical signs. There were no disturbances of the function of the great toe, nor of the posture or function of the foot as a whole, resulting from this anomaly.

Figures 1 and 2 show the anteroposterior roentgenograms of the feet of these patients and Figures 3 and 4, the plantar views. It is interesting to note that the medial sesamoid of the opposite foot in each case is of diminutive size.

Neither of these patients has children, and the parents of both are unavailable for roentgenographic study.

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FRACTURES AND DISLOCATIONS ABOUT THE SHOULDER *

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In reviewing the group of sixty-four fractures and dislocations about the shoulder, which have been treated at the University of Virginia Hospital during the past three years, and in correlating the methods of treatment and the results, one becomes more and more impressed with the conclusions of such masters as Sir Robert Jones that each separate problem presented in these fractures must be faced individually and that no one set of rules in regard to routine treatment can possibly apply. In one of his last articles, Sir Robert made a plea for the conservative treatment of fractures about the shoulder and, in speaking of fractures with dislocation, stated: "It is unscientific to suggest any routine method of reduction of the loose head". His treatment of all the fractures in this region was seasoned with the simplicity for which he was always noted. He had an inherent objection to the aeroplane splint.

Roberts, in his masterful article on fractures of the upper end of the humerus, emphasizes what we consider to be one of the most important adjuncts in the treatment of these fractures,—the taking of axillary-view roentgenograms to determine the anterior-posterior displacement of the fragments in order that the problem of reduction may be more clearly visualized. The taking of such views has been our rule for many years in treating all fractures about the shoulder. In the treatment of other fractures, we are not satisfied to depend on the appearance of the fragments in an anterior view only or in stereoscopic plates, and we cannot get a true conception of the clinical picture presented by fractures and dislocations about the shoulder without the knowledge derived from the lateral view.

Howard and Eloesser, in 1934, demonstrated very vividly in their phantom model, by means of rubber-band muscles attached to the bones composing the shoulder girdle, many of the mechanisms involved in fractures and in the reduction of fractures. But, unfortunately, such a model does not reproduce the reflex spasm and relaxation of the involved muscles. We are aware of such actions in the human, although it may be overcome to some extent by anaesthesia. These authors, however, like Sir Robert Jones, Roberts, Böhler, and Key and Conwell, have joined in sounding the death knell to the routine of complete abduction in plaster or splints.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

The conventional method of classifying fractures in the region of the shoulder has been as follows:

1. Separation of the upper humeral epiphysis;
2. Fracture of the anatomical neck;
3. Fracture of the surgical neck;
4. Separation and fracture of the tuberosities;
5. Fractures in the region of the glenoid;
6. Fractures of the acromion process and those involving the acromioclavicular joint;
7. Fractures associated with dislocation of the head of the humerus.

There have been numerous attempts by some authors, such as Kocher, and Howard and Eloesser, to make changes in the nomenclature which would more accurately describe these fractures, but so far such changes have not been generally accepted.

Probably the most difficult of all the fractures about the shoulder joint to reduce is a fracture of the humerus complicated by a dislocation of the head. Removal of the head has been advocated and resorted to by many surgeons (Trottier, Chalier). Such treatment should be reserved for cases which have been untreated for a number of weeks. It is not necessary to perform an open reduction in fractures of the tuberosities and of the neck as often as might be thought from the statements of Greeley and Magnuson, Frey, Sabadini, Chalier, and de Bernardi. However, in a few cases such a procedure is unavoidable.

Whenever possible, we have attempted to simplify the treatment of fractures of the shoulder by making use of the weight of the dependent arm in a swathe and neck-wrist strap to secure adequate protection over a short period of time with very early motion. During the earlier part of the three-year period from which the statistics contained in this paper were taken, many of the patients were treated with casts in abduction; whereas, later on, the Velpeau bandage or swathe was more frequently used. We are able, therefore, to make some comparison between the two methods of treatment.

One almost constant finding brought to our attention by the axillary-view roentgenograms is the anterior buckling of the fragments at the point of fracture, due to the spasm of the pectoral muscles. This buckling of the fragments must be corrected, so that the humerus, when healed, will rotate on its longitudinal axis.

The outstanding difference in our comparison of the two methods of treatment is in the condition of the muscles and joints at the end of the time of protective treatment. In cases where the cast was used, prolonged after-treatment was necessary. In the cases treated by the other method, free motion was usually present by the time of healing of the fracture.

In most of our cases of fractures of the neck and of the tuberosities, sufficient healing of the bone had taken place in about two weeks to allow motion and to prevent distortion from muscle pull. By conventional exercises such as swinging a two or three-pound weight,—first standing,

TABLE I

CASES OF FRACTURE OF THE NECK OF THE HUMERUS TREATED BY VELPEAU BANDAGE AND NECK-WRIST STRAP

Age Group (*Years*)	No. of Cases	Average Time in Velpeau Bandage (*Days*)	Average Time of Physiotherapy, Sling, and Strap (*Days*)	Average Time of Treatment (*Days*)
10–20	5	21	21	42
20–30	2	14	28	42
30–50	2	14	28	42
60–85	3	16	26	42

then bending gradually forward, then swinging laterally across the front of the body—muscle power and free motion in the joints have been restored at a very early stage.

The sixty-four cases of injury about the shoulder upon which this paper is based included forty-eight fractures, eleven uncomplicated dislocations of the shoulder, and five uncomplicated dislocations of the acromioclavicular joint.

UNCOMPLICATED FRACTURES OF THE NECK OF THE HUMERUS

There were twenty-seven cases of fracture of the neck of the humerus. From the standpoint of age, these occurred as follows:

Age Group	*Cases*
0– 5 years	1
5–10 years	1
10–15 years	8
15–20 years	2
20–30 years	5
30–50 years	4
50–60 years	1
60–85 years	5
Total	27

In this series, there were fourteen males and thirteen females; twenty-four were white and three were colored.

Of these twenty-seven patients, twelve were treated by means of a Velpeau dressing, with the arm against the side for an average period of nineteen days. This was followed by a neck-wrist strap for an average period of two weeks. (See Table I.)

Fifteen patients with fracture of the neck of the humerus were treated by casts with the arm in abduction for an average period of thirty days, followed by a sling for a period of two weeks,—a total of forty-four days of treatment before the return of function. (See Table II.)

FIG. 1

Anterior view of acromion, showing little evidence of injury.

FRACTURE OF THE NECK OF THE HUMERUS WITH DISLOCATION OF THE HEAD

In four cases, there was a fracture of the humeral neck and a dislocation of the head of the humerus. One of these patients was treated by closed reduction with a Velpeau bandage, followed by complete return of motion and function in ten weeks. In the second case, closed reduction was unsuccessful and open reduction was done ten days after the injury. The third patient refused treatment, and the fourth was treated by resection of the head ten weeks after attempted open reduction. The result in this last case was interesting in that there was return of motion of 60 per cent., and the patient was able to return to employment in a post office.

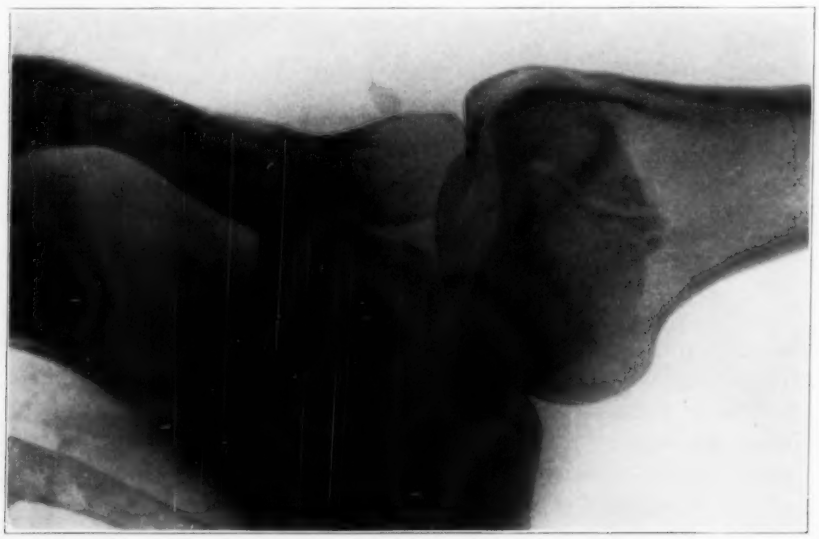

FIG. 2

Oblique view of shoulder shown in Fig. 1, revealing a complete fracture of the acromion process.

DISLOCATION OF THE HEAD OF THE HUMERUS

There were twenty-three cases of acute dislocation of the humerus: seventeen males and six females. Seventeen were white and six were colored.

Simple dislocation, unassociated with fracture, was found in eleven cases. Five of these dislocations occurred in the right arm and six in the left. All were subglenoid and anterior.

FIG. 3

Anteroposterior view, showing little evidence of injury.

In the other twelve cases, the dislocation was associated with fracture, as follows: fracture of the greater tuberosity, six cases; fracture of the neck of the humerus, four cases; fracture of the greater tuberosity and of the acromion process, one case; and fracture of the greater tuberosity and of the coracoid process, one case.

TABLE II

CASES OF FRACTURE OF THE NECK OF THE HUMERUS TREATED BY SHOULDER SPICA

Age Group (*Years*)	No. of Cases	Average Time in Cast (*Days*)	Average Time of Physiotherapy and Sling (*Days*)	Average Time of Treatment (*Days*)
0–5	1	28	14	42
5–10	1	24	16	40
10–20	5	32	15	47
20–30	3	33	11	44
30–50	2	35	7	42
50–60	1	28	14	42
60–85	1 *	28	14	42

* One other patient, aged eighty-one, died five days after leaving the hospital.

There were four recurrent dislocations which were treated by the Nicola operation, and one chronic dislocation, treated by open reduction and the Nicola operation six weeks after the dislocation had occurred.

The distribution of the dislocations according to age was as follows:

Age Group	*Cases*
0–15 years	0
15–20 years	3
20–30 years	4
30–40 years	2
40–50 years	7
50–60 years	3
60–85 years	4
Total	23

In the case of a simple dislocation, the average time of treatment before recovery of function was twenty-one days; in that of a complicated dislocation, forty-four days.

FIG. 4

Oblique view, showing fracture of tuberosity.

It seems very important that minute fractures in the region of the tuberosity be given the utmost consideration, for this type of injury may entail even more serious consequences than when larger chips of bone are detached. It is in this type of injury that we so often find a prolonged period of disability resulting from lack of thoroughness because of the apparent insignificance of the injury. The majority of these small fractures will heal without complication if given time, but, in two of our cases, it was necessary to repair the supraspinatus tendon. The clinical significance of this type has been brought out by Codman, Speed, Magnuson, and others.

ACROMIOCLAVICULAR DISLOCATION

There were five cases of acromioclavicular dislocation, including one associated with fracture of the outer third of the clavicle. All of these cases were treated by a primary Velpeau dressing with adhesive and pad strapping for an average period of two weeks, followed by a figure-of-8 bias-bandage dressing for a period of four weeks. In all cases, during the

period of observation, there was complete return of function without recurrence of dislocation.

It is unfortunate that x-rays taken in any one plane cannot be depended upon for a diagnosis of acromioclavicular dislocation. It is necessary that the diagnosis be made either clinically or by holding the shoulder girdle in a position which will maintain the dislocation while the x-ray is being taken.

FIG. 5

Typical oblique view of fracture near shoulder, showing type of displacement.

COMPLETE TRANSVERSE FRACTURE OF THE ACROMION PROCESS

Of particular interest were two cases of complete transverse fracture of the acromion process in which the diagnosis was made by the axillary-view roentgenograms combined with the history and clinical findings. These fractures could not be demonstrated by the anterior-posterior or stereoscopic x-rays. In each case treatment was by the Velpeau bandage and sling. Early motion with complete recovery resulted in the first case. The second patient is still under treatment. The condition, described by Köhler as delayed union of the acromial epiphysis, should not be confused with this type of fracture.

SUMMARY AND CONCLUSIONS

1. From the information and experience derived from the reduction, fixation, and after-care of sixty-four cases of injury about the shoulder joint, including fractures and dislocations, conservative treatment is urged.

2. Axillary-view roentgenograms are helpful in more clearly understanding the problem involved in reduction.

3. After reduction, the treatment of fractures and dislocations of the shoulder by casts or splints with the arm in the abducted position is unnecessary in most cases and contra-indicated in many.

4. X-rays taken from any one angle should not be relied upon for the diagnosis of acromioclavicular dislocations.

5. After reduction, the primary use of the Velpeau bandage or swathe with the elbow well across the chest, followed by a neck-wrist

strap and early exercises, tends to promote the maximum recovery of motion and function in the shoulder joint in the shortest time.

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OLD TRAUMATIC DISPLACEMENT OF THE DISTAL FEMORAL EPIPHYSIS

Successful Open Reduction Followed by Epiphyseal Arrest of the Normal Femur

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Complete traumatic epiphyseal separation in the lower end of the femur, with anterior displacement—so called "cart-wheel fracture"—is not as common today as it was during the horse-and-wagon age. Several decades ago, such injuries occurred more frequently and were due to the engagement of the leg between the spokes of a moving wheel. The leverage force usually causes the diaphysis to slip backward into the popliteal space, as the epiphysis slips anteriorly in front of the shaft of the femur, with its separated surface in contact with the lower end of the shaft. Because of the firm attachment of the periosteum at the epiphyseal line, there is considerable stripping of the periosteum. This is important in the consideration of the repair of such fractures. It is reported [1, 2, 4, 5] that the posteriorly displaced shaft may cause pressure upon the vessels and nerves. Gangrene of the limb from injury to the vessels, or sloughing of the skin from pressure, may occur. If the fracture is compound, suppuration may result. Paralysis, due to injury to the nerve, may complicate this fracture.

The diagnosis of a recent displacement is made from the history of a violent injury (usually occurring in a boy from nine to fourteen years of age) and the appearance of marked swelling at the knee joint, with shortening of the extremity and preternatural mobility. Circulatory or nerve disturbance may be present.

The treatment consists of immediate gentle reduction by manipulation under anaesthesia. This may be accomplished by flexion of the knee and the exertion of traction in two planes,—that is, in the axis of the femur and in the axis of the leg. Pressure of both thumbs above the condyles of the femur, while the traction is being exerted, will aid in the reduction. The knee is flexed to a right angle and a plaster-of-Paris cast is applied. This cast is worn for two weeks. At the end of this period, the knee is flexed to 135 degrees and another cast is applied. This, in turn, is removed at the end of two weeks. The knee is then brought to 180 degrees and a third cast is applied. This cast is worn for one to two weeks.

The treatment of an old unreduced separation of the distal femoral epiphysis presents a more complicated problem, as shown by the following case.

W. D., a boy, aged thirteen, was admitted from the Out-Patient Clinic to the writer's Service at Cook County Hospital, May 18, 1933, with a history of having been kicked in

back of the left knee by a horse seven weeks prior to admission. Roentgenograms, made at a small country hospital near the scene of the accident, had been reported "negative", but a plaster-of-Paris cast had been applied. This cast had been worn for several weeks.

The complaint on admission was limitation of flexion of the left knee to 160 degrees and shortness of the left lower extremity of approximately one and one-half inches. The patient walked with a marked limp.

FIG. 1-A

FIG. 1-B

Roentgenograms showing displacement of the distal epiphysis of the left femur, with firm bony union.

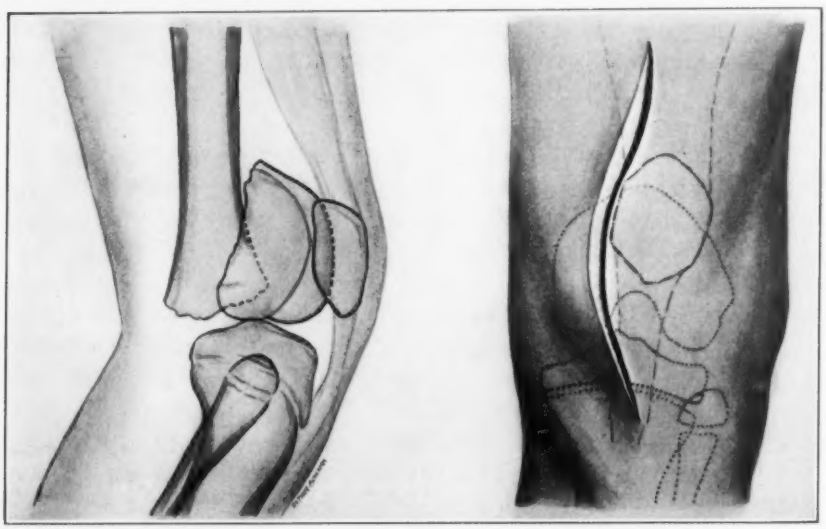

FIG. 2-A

Drawing of Fig. 1-A, showing the pathology.

FIG. 2-B

Drawing of Fig. 1-B, showing the line of incision.

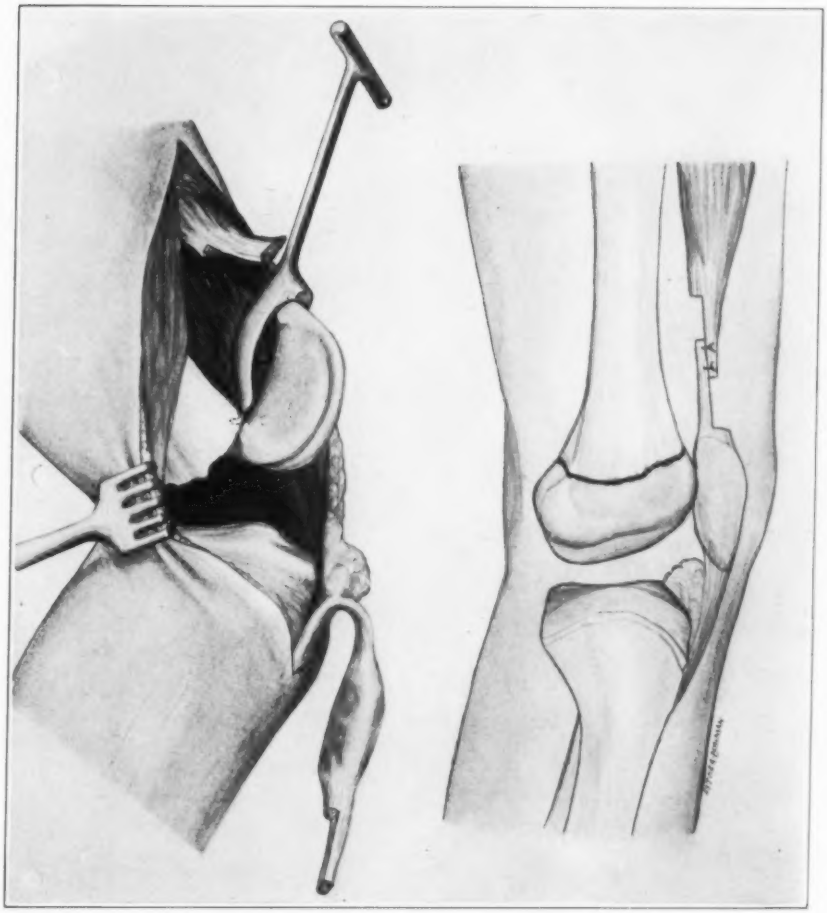

FIG. 3-A

Tenotomy of the quadriceps by the Z-plastic operation. The condyles are separated from the anterior aspect of the shaft. Then, while the knee joint is flexed, the author's bone skid is used to replace the epiphysis.

FIG. 3-B

Showing the repair of the quadriceps with lengthening of the fragments and restoration of their normal apposition.

Roentgenograms (Figs. 1-A and 1-B) showed a complete anterior displacement of the distal femoral epiphysis, the distal end of the diaphysis resting upon the articular surface of the tibia. Considerable callus was shown beneath the raised periosteum, particularly on the medial border of the shaft of the femur.

Under ether anaesthesia, and with tourniquet hemostasis, a long anteromedial incision was made in the lower third of the thigh and knee joint. The quadriceps tendon was incised by the Z-plastic operation on the flat surface, exposing the femoral condyles which were found firmly attached to the anterior surface of the lower end of the diaphysis (Fig. 2-A). The epiphysis was separated by chisel and mallet. By means of the author's bone skid and simultaneous gradual flexion of the knee, the epiphysis was replaced distal to the diaphysis (Figs. 3-A and 3-B).

A plaster-of-Paris cast was applied for six weeks, followed by the institution of physical therapy. A wedge cast was then applied to correct flexion contracture.

Eight months after the first operation, the range of motion was 180 to 100 degrees,

FIG. 4-A FIG. 4-B

Anteroposterior and lateral views of the left femur, eight months after open reduction.

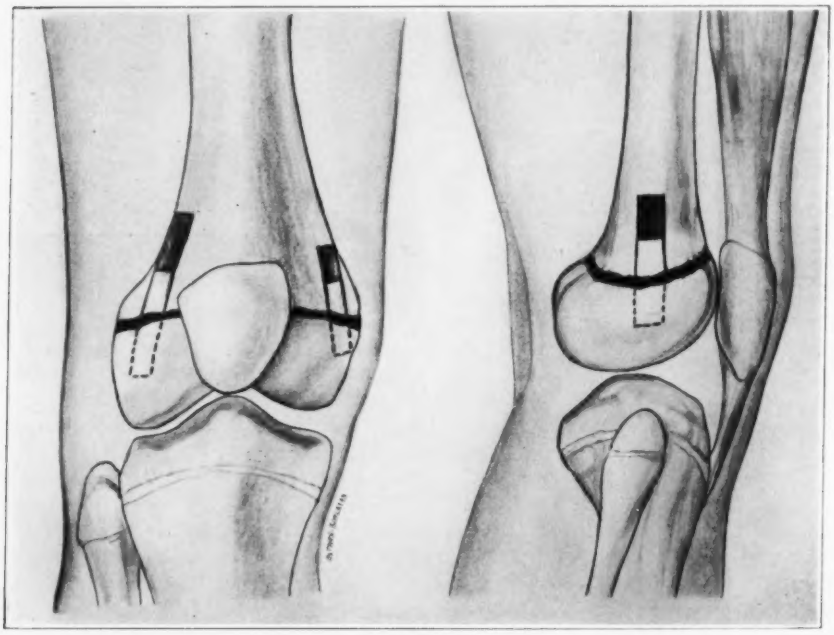

FIG. 5

Sketches representing method of epiphyseal arrest. The cartilage plate has been thoroughly curetted and packed with small bone grafts. Two larger grafts from the diaphysis are *driven into* the epiphyseal condyles half-way across the epiphyseal line.

FIG. 6-A

FIG. 6-B

About eleven months after epiphyseal arrest. Photographs showing the contour and range of motion of the injured (left) leg, as compared with its mate. The right knee has a normal range of motion and the left has a range from 180 to 100 degrees.

and the roentgenograms (Figs. 4-A and 4-B) showed a normal relation of the fragments, with fusion of the epiphyseal line. It was immediately decided to do an epiphyseal arrestment [3] of the normal (right) side, to which the mother of the patient objected. However, fourteen months after the first operation, when there was one-half an inch of shortness, the mother finally consented to arrestment of growth of the lower femoral epiphysis of the normal side.

The patient was readmitted to the Hospital on July 14, 1934, and was operated upon on July 18, 1934. Under ether anaesthesia, and with tourniquet hemostasis, medial and lateral incisions, two and one-half inches long, were made over the condyles of the right femur. The epiphyseal line was exposed and the cartilage plate was thoroughly curetted. A number of small grafts were placed between the epiphysis and the diaphysis. Small sliding bone grafts from the diaphysis, one inch by three-eighths of an inch, were placed across the epiphyseal line medially and laterally (Fig. 5). A cast was applied from the groin to the toes.

FIG. 6-C

The patient was discharged from the Hospital on July 31, 1934. The cast was worn for six weeks and then physical therapy was started, together with active use. Complete motion was regained in three weeks. Roentgenograms, made three months after the operation, revealed definite closure of the epiphyseal line. Figures 6-A, 6-B, and 6-C show the present contour and range of motion of the knees. The boy walks without a limp and participates in major sports.

Scudder has reported a similar case in a boy seven years of age, in which the displacement was reduced by open operation.

CONCLUSIONS

This case is of interest for several reasons:

1. It presents a rather unusual injury, with the distal femoral epiphysis displaced and united anteriorly to the metaphysis.

2. Although shortness of the extremity of one and one-half inches was present, it was possible to secure by operation an anatomical reduction with restoration of normal length.

3. The equality of the extremities was maintained by arresting the growth of the opposite distal femoral epiphyseal plate.

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SUPRATROCHANTERIC CALCIFICATION

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Calcified deposits in the region of the greater trochanter are potential causes of pain and disability referable to the hip. In a review of the roentgenograms of 650 hip joints, it was found that 100 were of patients less than fifteen years of age and that 550 were of patients between the ages of fifteen and sixty-nine. In the first age group, there was no roentgenographic evidence of calcified deposits about the region of the greater trochanter. In the second group, such deposits were observed in thirty cases, or 5.4 per cent. Therefore, while unusual, this syndrome is by no means rare. At the time of the first consultation, the average age of this group of thirty patients was forty-five years.

In an effort to determine the etiology and outcome of these thirty cases, the records of the Out-Patient Department were investigated. In only twenty-five cases were the records sufficiently complete to warrant inclusion in this study. Of these twenty-five patients, 64 per cent. gave a history of trauma; 24 per cent. presented foci of infection; and 12 per cent. showed evidence of osteo-arthritis elsewhere. The predominant limitations of motion were abduction and internal rotation, due to reflex spasm of the gluteus medius. An analysis of the roentgenograms showed that the calcified deposits varied in size from that of a small pea to the mass described in Case 1.

Roentgenographic and anatomical evidence seems to indicate that there are three different locations for calcified deposits in the region of the greater trochanter:

1. In the tendon of the gluteus medius. (See Case 3.)
2. In the bursa between the tendon of the gluteus medius and the greater trochanter. (See Case 2.)
3. On the under surface of the gluteus medius and not connected with the trochanter. (See Case 1.)

In the region of the greater trochanter, three separate and distinct bursae are present:

1. *Gluteus Maximus:* The most constant and important bursa of the gluteus maximus lies between this muscle and the tendon of the gluteus medius. This bursa is large in size and is generally multilocular.
2. *Gluteus Medius:* A constant bursa lies between the tendon of this muscle and the greater trochanter.
3. *Gluteus Minimus:* A small inconstant bursa lies between this muscle and the greater trochanter.

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Of the thirty positive roentgenograms, twenty showed the deposits to be in the tendon of the gluteus medius; eight, in the bursa between the tendon of the gluteus medius and the greater trochanter; and two, on the under surface of the gluteus medius and not connected with the trochanter.

One possible etiological source may be an osteophyte, such as is shown in Case 4, which by its presence may stimulate degenerative changes, resulting in calcification in the muscle or tendon.

It is possible that trauma about the hip joint may be of sufficient intensity to avulse a portion of the trochanter. However, since the tendon of the gluteus medius is almost without blood supply and since the average age of our group of patients is forty-five years, it is more likely that a partial tear of the tendon occurs. The partially torn tendon will then undergo a local necrosis, and, as is usual, these areas will become foci for calcification. Calcified deposits are associated with inflammatory changes in the neighboring tissues, resulting in a swelling of the walls of the tendons and bursae, so that motions which approximate the greater trochanter and acetabulum will cause pain, and this phenomenon corresponds to the clinical picture.

DISCUSSION

It is evident that the pathogenesis of this syndrome is analogous to the syndrome which occurs in the supraspinatus muscle at the shoulder joint.

In the discussion of calcification about the shoulder, Brickner states that, "as a result of contusion or tear of the tendon, there is formation of granulation tissue, necrosis of the tendon substance, and a deposition of lime". Codman believes that rupture in the case of the supraspinatus tendon "occurs in the great majority of cases in aged tendons made weak by overuse, age, or toxic conditions". Stieda described a somewhat similar condition in the ligaments of the knee joint following trauma.

In the non-osseous skeletal tissues, calcification is almost always the result of trauma. As a result of trauma, there follows hemorrhage, organization, and, at times, calcification and ossification, as described by Leriche and Policard. A trauma may be so slight, or may have occurred so long a time before the onset of symptoms, that the patient does not think of it in relation to his present complaint. Deposits, however, may be present without symptoms.

One distinction, however, must be recognized in this syndrome as it occurs in the hip and as it occurs in the shoulder. Because of its relatively small size and limited area of insertion, the supraspinatus tendon is more often liable to complete rupture than is the larger tendon of the gluteus medius. In the latter instance, a relatively large area of degeneration can occur, completely involving the tendon. Therefore, at the hip, it is not necessary to postulate a ruptured tendon in the presence of evident calcification.

The following five cases are reported in detail because they demon-

FIG. 1

Case 1. Roentgenogram of the left hip joint before operation, showing a calcified deposit on the under surface of the gluteus medius, not connected with the greater trochanter.

FIG. 2

Case 1. Postoperative roentgenogram of the left hip joint, revealing complete extirpation of the calcified deposit.

strate varying aspects of the syndrome under discussion. Taken as a group, they give a composite picture of calcified deposits about the greater trochanter.

CASE REPORTS

CASE 1. C. L., a male, aged fifty-five was admitted to the Hospital for Joint Diseases on February 5, 1934. He had been well until October 1933, when he had fallen out of a tree, injuring the region of the left hip. The pain in the hip had persisted and the patient had been unable to work.

Examination of the injured hip revealed that the extremity was held in slight adduction. There was no tenderness. Adduction and external rotation were complete. There was marked limitation of abduction, slight limitation of internal rotation, flexion to 90 degrees, and extension to 170 degrees. Beyond these limits, the patient had pain in the region of the hip. Roentgenographic examination (Fig. 1) revealed a calcified deposit in the region of the capsule of the left hip. The blood count and urine were normal. The Wassermann, Kahn, and gonorrhoea complement fixation tests were all negative.

The patient was operated upon on February 6, 1934. Directly beneath the deep fascia a huge mass of bone was felt. The tensor fasciae femoris was retracted outward. A mass of bone, two inches in length and one and one-quarter inches at its widest part, was resected. This mass was embedded in the soft tissues adjacent to the joint capsule on its deep surface, the gluteus medius on its outer aspect, and the rectus femoris in front. The bone was easily shelled out. The specimen consisted of a flat piece of bone, covered on one side by ligamentous tissue; on the opposite side connective tissue and fat were attached. Microscopic examination showed the flat mass to consist of cartilage which was undergoing ossification. On one surface, the connective tissue contained more fat, and a few necrotic muscle fibers were to be seen. The roentgenogram (Fig. 2), taken after operation, revealed complete absence of the calcified plaque previously reported.

After his discharge from the Hospital, the patient complained of slight stiffness, for which he received diathermy, baking, and massage. After seven treatments, he had a complete range of painless motion. The patient has been back at his former occupation of tight-rope walking since October 3, 1934.

CASE 2. N. M., a male, aged fifty-six, complained of pain in the right hip joint, with radiation down the outer aspect of the right thigh, of eighteen months' duration. For the past two years, the patient had worn a truss for hernia.

Examination showed the patient to be in good general condition. He walked without a limp. There was moderate tenderness over the right greater trochanter. The motion of the hip was free in all directions, except abduction and internal rotation, which were limited to 20 degrees and 15 degrees, respectively. The patient had an incomplete, indirect right inguinal hernia. The ring of the truss rested on the right greater trochanter.

Roentgenographic examination (Fig. 3) disclosed a calcified bursa of the right greater trochanter. Diathermy brought no relief; therefore, excision of the bursa was advised, which the patient refused.

CASE 3. M. B., a female, aged fifty-eight, complained of slight but steady pain in the region of the left hip. There was no history of trauma. The patient stated that she had been perfectly well until two years previously, when she had been awakened from sleep by a sharp pain in the region of the left hip. The pain had gradually decreased, but had never entirely disappeared.

Examination showed that the patient walked by dragging the left lower extremity. Active abduction was painful and was limited to 30 degrees. There was tenderness over the hip joint and over the greater trochanter. The roentgenogram (Fig. 4) showed a small bone lying in the gluteus medius over the greater trochanter.

CASE 4. R. P., a female, aged forty-seven, attributed her illness to a fall on the left

FIG. 3

Case 2. Calcified deposit within the bursa of the gluteus medius.

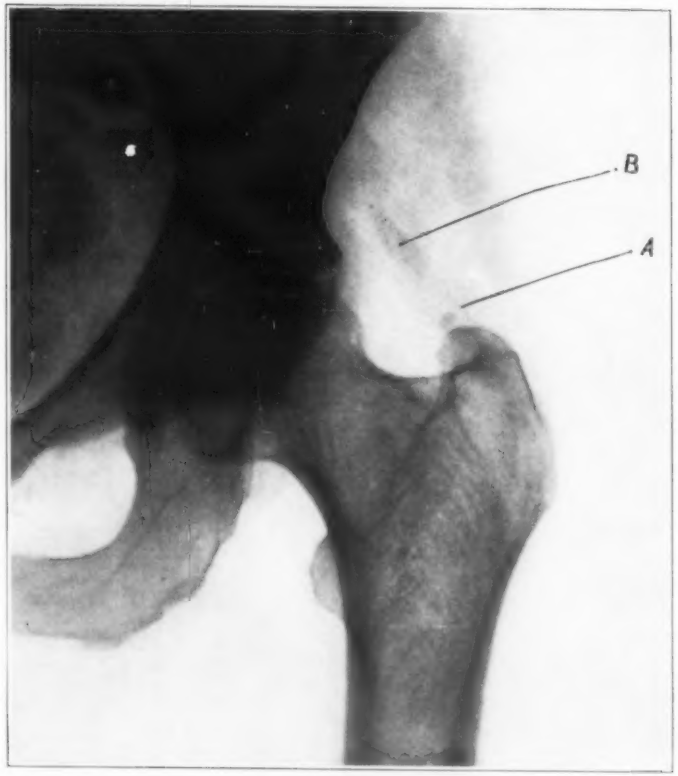

FIG. 4

Case 3. Roentgenogram showing:
A. Small calcified deposit in the tendon of the gluteus medius over the greater trochanter;
B. Gluteus medius.

FIG. 6

Case 5. Calcified deposit in the bursa of the gluteus medius, with osteo-arthritis of the left hip.

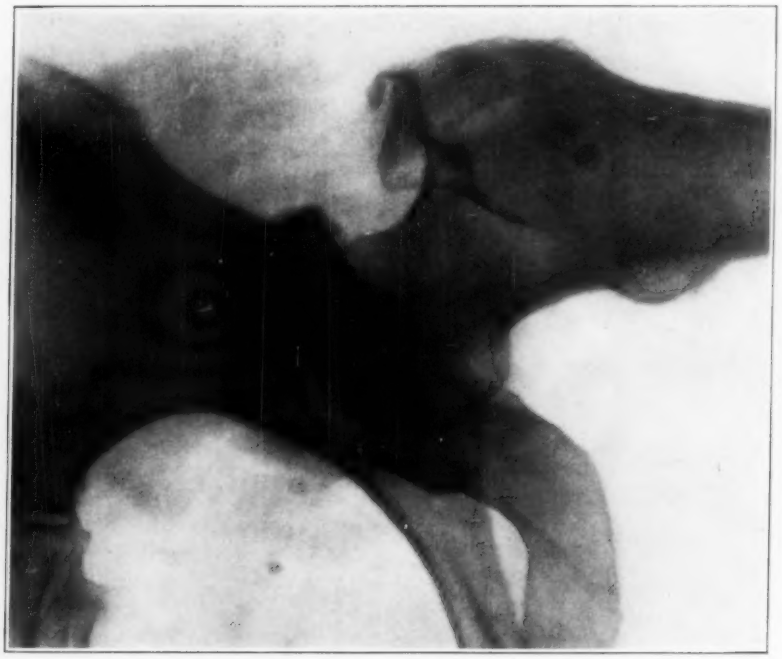

FIG. 5

Case 4. Osteoperiosteal spur on the greater trochanter.

hip two months before admission. The roentgenograms taken at that time were said to have been negative. Pain had been present in the region of the left hip for three weeks; then it had subsided. Two weeks before admission, the pain had recurred.

Examination showed that the patient walked with a slight limp on the left side. There was limited motion in all directions and tenderness over the left greater trochanter. Roentgenographic examination (Fig. 5) showed an osteoperiosteal spur on the left greater trochanter.

The patient received seven diathermy treatments, with some relief of pain.

CASE 5. M. B., a male, aged forty-six, complained of pain in the left hip and a limp of eighteen months' duration. One and one-half years before admission, he had fallen, injuring the left hip. Pain had been present for about one week; then it had gradually subsided. Six months later, the pain had recurred and had persisted. At no time had the pain been severe.

Examination showed that the patient walked with a limp on the left side. Motion in the left hip joint was limited in all directions. There was no tenderness over the greater trochanter. There was three-eighths of an inch of shortening of the left lower extremity.

The roentgenogram (Fig. 6) revealed an arthritis of the left hip, with calcification of the bursa.

The patient received thirteen diathermy treatments, without any apparent improvement. Operative removal of the calcified mass was advised, but was refused by the patient.

SUMMARY

1. Calcification in the region of the greater trochanter should be suspected in cases of pain in the region of the hip.

2. There are three common locations for calcified deposits in the region of the greater trochanter.

3. The pathogenesis of this syndrome is analogous to the syndrome which occurs in the supraspinatus muscle at the shoulder.

4. Deposits may be demonstrated in the roentgenogram, and the patient may have no signs nor symptoms. The most frequent clinical sign is reflex spasm of the gluteus medius.

5. Review of the literature and our experience show that surgical removal of the deposit results in a cure.

The authors wish to thank Dr. Samuel Kleinberg for permission to use several of his cases, and Dr. E. M. Bick for his assistance in preparing the manuscript.

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TOTAL DISLOCATION OF THE ASTRAGALUS

BY JOSEPH I. MITCHELL, M.D., MEMPHIS, TENNESSEE

Complete and simultaneous dislocation of the astragalus, from the tibiotarsal mortise, from the calcaneum, and from the scaphoid is of infrequent occurrence and, although the dislocation is described in most text-books on traumatic surgery, the mechanism is not clearly understood. Five varieties of this lesion have been recognized,—namely, forward, backward, medial, lateral, and rotary. According to Stimson, the most common variety is the forward dislocation, of which the following case is an example.

I. T., a negro woman, aged thirty-five years, weighing 231 pounds, was admitted to the Orthopaedic Service of the Memphis General Hospital on February 25, 1935, eighteen hours after injury to the right ankle. The right foot and lower leg were swollen. The knee was held flexed and the foot was displaced medially, inverted, and in equinus. The medial malleolus was not palpable; the lateral malleolus was prominent. A bony mass

FIG. 1

Anteroposterior view of the ankle showing lateral displacement of the astragalus from its articulation with the tibia and the calcaneum.

FIG. 2

Anteroposterior view of the foot, showing the head of the astragalus displaced from the scaphoid and lying lateral to the cuboid.

FIG. 3
Lateral view, showing anterior displacement of the astragalus.

was present on the dorsal surface of the foot, and the skin overlying this mass was stretched taut and was beginning to slough.

Roentgenograms of the foot and ankle, made in several planes, demonstrated a complete dislocation of the astragalus laterally and anteriorly from its normal position. The body of the astragalus was displaced anteriorly, but was still partially within the tibiofibular mortise. The inferior surface was separated completely from the calcaneum, and the head of the astragalus was lying lateral to the cuboid bone. The other tarsal bones were in a normal position and no fracture was identified.

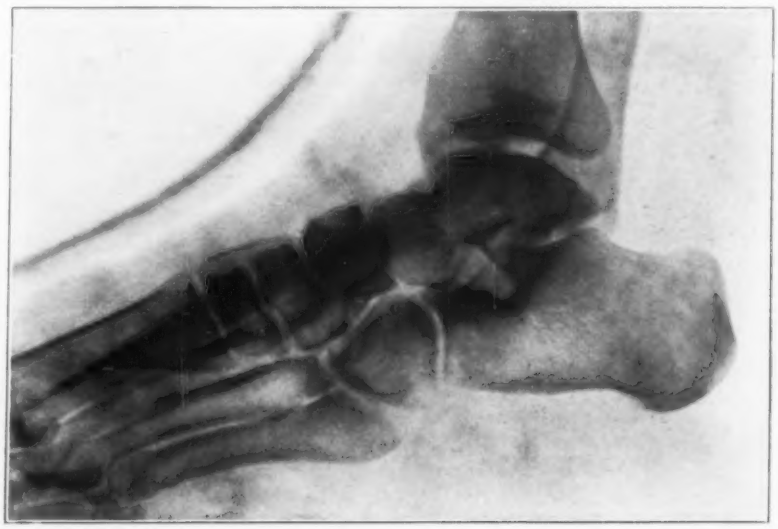

FIG. 4
Roentgenogram of the foot and ankle after closed reduction and application of a cast.

Preparations were made for an operative reduction or possible excision, since it was believed that successful reduction by closed manipulation was doubtful. With the patient under spinal anaesthesia, which produced complete muscular relaxation, manipulation was performed in the following manner. One assistant supported the leg with the knee flexed at a right angle. A second assistant grasped the heel and forefoot, making strong traction. Direct pressure with both thumbs was then exerted over the prominent head and body of the astragalus. The displacement was quickly and easily reduced at the first attempt and the normal contour of the foot was restored. A plaster cast, extending from the base of the toes to the knee, was applied, and a balsa-wood foot plate was incorporated for walking.

The patient was discharged from the hospital five days later, bearing full weight. The first cast was changed after six weeks and a second cast was worn for four weeks. When the patient was last seen in the Out-Patient Department five months after the injury, function of the ankle was practically normal.

The patient's account of the accident was that she had slipped on ice and had fallen down four steps. It was impossible to ascertain the exact mechanism of the injury, but, since the heel of the right shoe was broken, it was presumed that this shoe heel had caught on the step. As the patient fell forward, the foot was forced into strong plantar flexion, thus widening the anterior aspect of the ankle joint. At the same time, pressure from the weight of the body was exerted on the astragalus from above and behind. In this manner, the astragalus was presumably squeezed from its position, as a pea is squeezed out of a pod.

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INTERESTING MALIGNANT BONE TUMORS

BY OTHO C. HUDSON, M.D., NATHANIEL H. ROBIN, M.D., AND PERCIVAL A. ROBIN, M.D., HEMPSTEAD, NEW YORK

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The following six cases of malignant bone tumors are interesting from a diagnostic viewpoint and include: (1) metastatic carcinoma of the breast, resembling hyperparathyroidism; (2) endothelioma of the pubis; (3) Hodgkin's disease, with osseous metastases; (4) metastatic adenocarcinoma, resembling primary osteogenic sarcoma; (5) metastatic carcinoma to bone from the cervix; (6) telangiectatic sarcoma of the humerus.

The problems for diagnosis have in most cases been clinical as well as roentgenographic. No effort has been made in this paper to review the literature.

CASE 1. A. C., white, female, aged fifty-six years, a housewife. (Registry of Bone Sarcoma, No. 1849.)

The patient was admitted to Nassau Hospital on February 26, 1935. Twelve years previously, a radical breast amputation had been done for carcinoma. Eight months before admission, pain had developed in the right elbow, with limitation of motion. Six months later, a marked constipation had developed. She had lost sixty-five pounds in weight during the year. The pain in the elbow had persisted and become constant. Upon admission, the patient complained of severe pain in the lumbosacral spine of a week's duration, with radiation down the posterior aspect of the left thigh.

Physical examination disclosed an adult in poor general condition. The right elbow was swollen, with extreme limitation of motion in all directions. There was tenderness over the humeral shaft. Flexion deformities of both hips were present, with tenderness over the ilium and upper third of the left femur.

The blood Wassermann and urine tests were negative. The blood count showed a secondary anaemia.

Blood examination, on one occasion, showed:

Calcium—14.4 milligrams per 100 cubic centimeters

Phosphorus—3.5 milligrams per 100 cubic centimeters

and a later examination showed:

Calcium—12.0 milligrams per 100 cubic centimeters

Phosphorus—3.4 milligrams per 100 cubic centimeters.

Roentgenograms of the right elbow revealed extensive cystic degeneration of the humerus and upper end of the radius and ulna, with destruction of the cortex in some areas.

Roentgenograms of the skull, pelvis, femora, and lumbar spine showed the entire cranial vault to be filled with numerous areas of decreased density without thickening of the tables. The lumbar spine, pelvis, ribs, and femora showed the same changes noted in the humerus.

The patient's condition grew steadily worse during hospitalization. On March 8, 1935, the face was partially paralyzed. A week later, a diffuse bronchopneumonia developed and the patient died on March 16, 1935.

At autopsy, there was found a mass at the anterior edge of the left axilla in the subcutaneous tissues. The pleura was much thickened on both visceral and parietal surfaces and appeared grayish-white and somewhat nodular. In the hilum at each lung the main bronchi were surrounded by very firm grayish-white tissue. The spleen showed

numerous small zones of grayish-white tissue. Retroperitoneal tissues, extending from the pelvis up into the thorax, revealed numerous deposits of grayish-white, hard tissue apparently in lymph nodes. Some of these were two centimeters in diameter and many were adherent to each other.

The crest of the ilium was revealed on the left side and was found to be greatly thickened. The periosteum was adherent. A portion of the crest of the ilium was removed and section disclosed destruction of the usual cancellous structure and replacement by solid masses of pale tissue of fibrous consistency. The thickness had been increased to about one and one-half centimeters at the crest and to two and one-half centimeters in the body of the ilium. A section of the lumbar vertebrae showed similar alteration of the bone structure. Similar masses of tumor tissue were revealed in the ribs, expanding the usual contours. Such was the case in the third rib, in the axillary line, where the subcutaneous mass was located. The right humeral shaft was encased in an indurated grayish-yellow tissue which infiltrated the muscle attachments. The periosteum was invaded so that it no longer formed a separate layer. The whole marrow cavity appeared to be filled with this hard substance and there was no longer the distinction between cortex and marrow cavity.

The diagnosis was carcinomatous metastasis to the vertebrae, ribs, right humerus, pelvis, left femur, pleura, and to the lymphatics in the hila of the lungs, the posterior mediastinum, and the retroperitoneal tissues.

This case is of interest because of the long interval of time (twelve years) which elapsed between the original mastectomy and the development of the metastatic bone lesions.

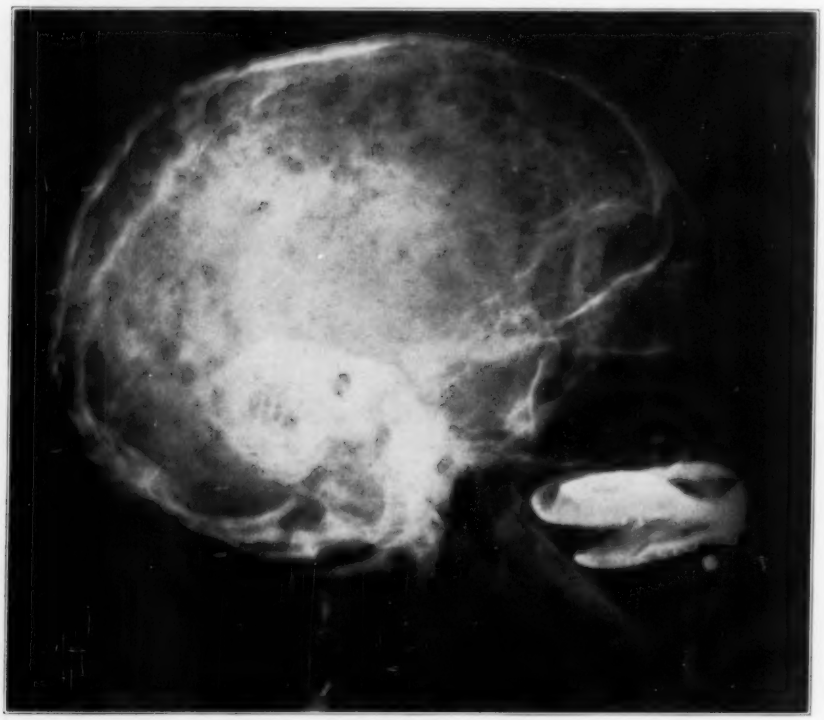

FIG. 1

Case 1. X-ray of skull, March 1, 1935, showing extensive destruction of the cranial tables.

FIG. 2

Case 1. X-ray of pelvis, March 1, 1935, with barium enema, showing extensive destruction of all bones visualized. The cortex here remained intact.

FIG. 3

Case 1. X-ray of right elbow, February 27, 1935, showing extensive osseous changes.

The clinical picture resembles very closely that of hyperparathyroidism, with loss of weight, high blood calcium, low phosphorus, and generalized polycystic changes in the bones. Our original diagnosis in this

case was osteitis brosa ficystica, but biopsy proved this diagnosis to be erroneous.

The increase of blood calcium and the decrease of blood phosphorus occurs in generalized metastatic carcinoma, as well as in hyperparathyroidism. However, the phosphatase figure is the important differential point, as far as the blood picture is concerned. Unfortunately, our laboratory is not equipped to give this reading.

Another differential point, as revealed by the roentgenographic examination, was the fact that these so called cystic lesions in the humerus had broken through the cortex. This condition is generally seen only in malignancy and occasionally in osteitis fibrosa cystica. One more important factor in the differential diagnosis was the roentgenographic appearance of the skull. In this case, the areas of destruction were large, as one would expect with carcinoma, while in osteitis fibrosa cystica the usual picture is that of a fine granular mottling.

One point, however, in favor of hyperparathyroidism was the fact that all the bones which were x-rayed showed a generalized osteoporosis. This finding is frequently the first bone change seen in this disease.

CASE 2. J. S., white, female, aged fifteen years, a student.

The patient was admitted to Nassau Hospital on June 12, 1934, with a history of pain in both knees of five months' duration, loss in weight of twenty pounds, and anorexia.

Physical examination showed hyperpyrexia, tachycardia, and malnutrition. Flexion contractures were present in both knees. Blood counts showed marked secondary anaemia. All other laboratory findings were negative.

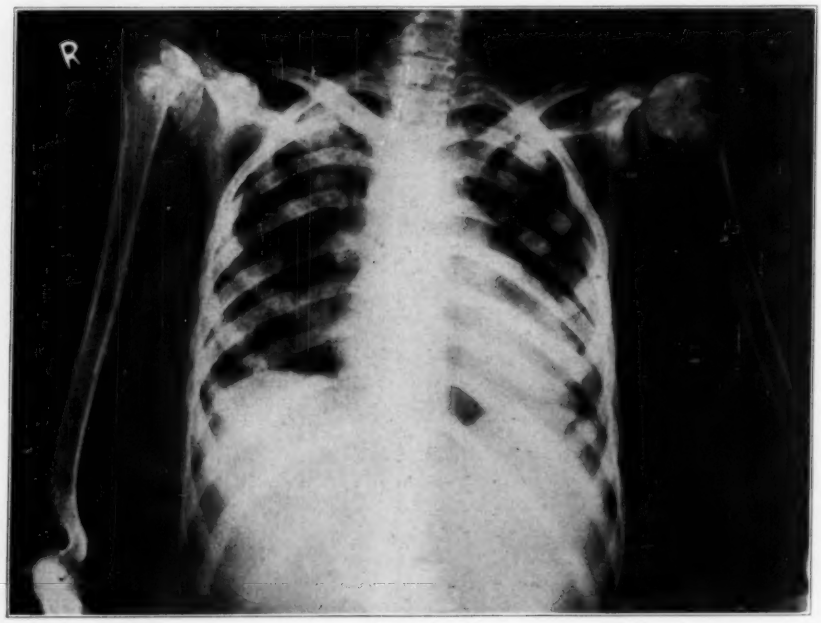

FIG. 4

Case 2. X-ray of chest, August 8, 1934, showing metastatic lesions to lungs, ribs, and shoulder girdles.

The patient steadily became worse, with loss of strength, weight, and appetite. The anaemia increased, and transfusions were given. Roentgenograms of the pelvis showed multiple areas of destruction throughout the pelvis and upper ends of both femora. Destruction was most marked in the horizontal ramus of the left pubic bone and in the ramus of the left ischium. Productive changes had also taken place in this region.

The patient was transferred to the Nassau County Tumor Clinic on August 7, 1934. Physical examination showed an extremely emaciated girl. There was engorgement of the superficial veins of the left side of the abdomen, extending down on the left thigh. The left inguinal region was fuller than the right. There was no tenderness over the pelvis. There was oedema of the left leg and knee. Flexion contractures of both knees were present; the contracture of the left knee was greater than that of the right. Motion of the left hip was very painful.

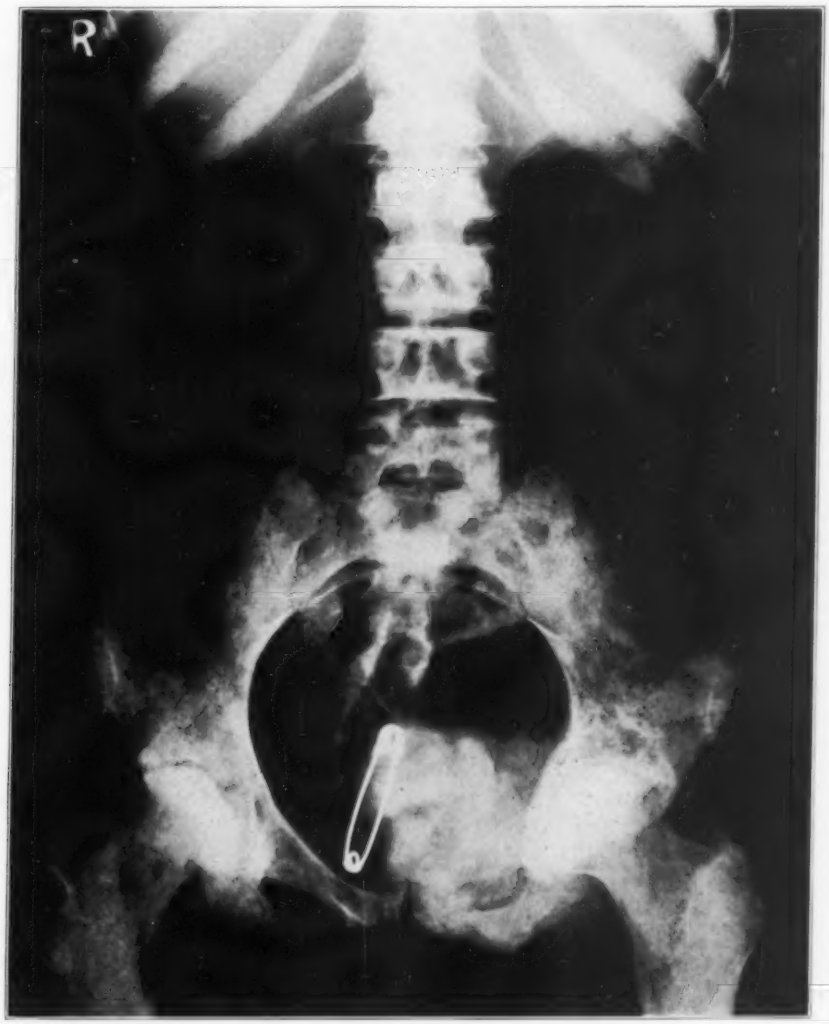

FIG. 5

Case 2. X-ray of pelvis, August 8, 1934, showing a large destructive and productive lesion of the left pubic bone with extension.

The impression was that this was a case of endothelial myeloma.

Roentgenographic examination of the chest, on August 8, 1934, showed a dense oval shadow in the left lower lobe, due to metastasis. Surrounding it was an inflammatory process. There were also noted multiple small areas of rarefaction in the ribs, the outer end of the right clavicle, and the upper end of the right humerus.

Roentgenograms of the pelvis showed multiple areas of destruction throughout, involving the femora and the sacrum. There was a more advanced lesion in the left pubis, with a large amount of new bone.

On September 4, 1934, radiotherapy was administered to the pelvis. Later, ptosis of the right eyelid developed, with diminution of all external ocular movements. The patient complained of severe pain in the right temporal and frontal areas. The right temporal region, including the orbit, was then irradiated, with relief of symptoms. Several weeks later, pain developed in the chest, due to metastases, and the left chest only was irradiated. The patient's condition followed a downhill course and she died in a coma on November 11, 1934.

Autopsy revealed an extremely emaciated dehydrated child. There were nodules attached to the ribs in the region of the costochondral articulations. The skull presented numerous nodules, ranging in diameter from one to three centimeters. There was a nodule in the left orbit above the globe. There were numerous nodules beneath the parietal pleura and attached to the ribs. The right lung was adherent to the parietal pleura over some of these nodules. In the lower lobe of the left lung, near the mediastinal border, there was a large tumor mass. The liver showed a few nodules of tumor, and the spleen contained a single nodule. The bladder was displaced to the right and posteriorly by a tumor mass in the pelvis. There were numerous nodules of tumor in all of the ribs, most marked at the costochondral junction. The nodules on the right side of the chest were one and five-tenths centimeters in diameter at the costochondral junction; those on the left side were smaller. There were smaller metastases present in the bodies of the ribs. Involving the pubis, was a large, irregular, nodular mass, extending somewhat more to the left than to the right. This mass extended downward on either side along the pubis and down the ascending ramus of the ischium. On the left side, the iliac vein was involved in a mass and contained a solid cord of tumor tissue up to its junction with the vena cava. The color of the tumor was an unusually bright yellow. Other areas of the tumor were gray in color and in some places were necrotic.

The final pathological diagnosis by Dr. F. W. Stewart, of New York City, was as follows: "This case presents certain peculiarities; the cells are in many places too spindle-shaped for the usual endothelial tumor. Yet there are rosettes, peculiar whorls, and, particularly in the bronchial node, the structure corresponds to endothelioma. The calcification which, in gross, I thought was against endothelioma is in areas of hemorrhage and necrosis and hence does not militate against the diagnosis of endothelioma. I think we are justified in accepting the tumor as a form of endothelioma of bone."

In this case, the left side of the chest received a single high-voltage x-ray treatment. The tumor masses, arising from the ribs beneath the pleura on the posterior aspect of the thoracic cavity, were larger and more numerous on the right than on the left. The apparent regression of the tumor on the irradiated side of the chest is noteworthy.

This case presents the usual difficulty of making a diagnosis before osseous changes have occurred. Symptoms persisted for eight months before positive roentgenograms were obtained. We have recently seen a case of metastatic epidermoid carcinoma of the ilium in which the same symptoms were noted.

In both cases, the pain was referred to the knees, with later develop-

FIG. 6

Case 3. X-ray of the pelvis, January 29, 1935, showing periostitis of the ilium and femur, as well as osteoblastic changes in the innominate bones and lumbosacral spine.

FIG. 7

Case 3. X-ray of the pelvis, August 7, 1935, after radiation therapy, with regression of the tumor.

ment of flexion contractures. It might be of help in treating patients with obscure pain in the knees without evident cause to be on the watch for a primary neoplasm of the pelvis.

CASE 3. A. F., white, male, aged twenty-two years, a farmer.

The patient was admitted to Nassau Hospital on January 29, 1935. Five months previously, pain had developed in the sacral region. This pain was described as a steady dull ache, and it had not been relieved by medication. Three weeks prior to admission, the pain had become worse in back and had radiated to both thighs. Two weeks before admission, there had been some vomiting after meals. The patient stated that he had felt very weak for several months and had been unable to work. He had lost twenty-five pounds in five months. There was anorexia.

Physical examination showed an adult male, acutely ill, with generalized adenopathy. There was tenderness over the sacrum and the sacrococcygeal region, and marked tenderness over both acetabula.

Roentgenographic examination of the pelvis, on January 29, 1935, showed a generalized sclerosis of bone which appeared to involve the sacrum and the lower lumbar vertebrae. Along the lateral margins of the iliac bones, there was a periosteal reaction, extending down to just above the acetabula. On the left side the sun-ray appearance was evident. Along the medial margin of the neck of the right femur and extending down the shaft for some distance, there was a periostitis similar in all its characteristics to that seen along the left iliac bone. On the lateral side of the right femur there was simply thickening of the periosteum.

The blood Wassermann and urine tests were negative. Blood counts showed mild anaemia and leukocytosis.

With rest in bed, the subjective pain was relieved and the vomiting ceased. The temperature was 99 to 100 degrees continuously. Biopsy of an inguinal node was done on February 2, 1935. The microscopic diagnosis was Hodgkin's disease.

On February 8, 1935, the patient was referred for deep x-ray therapy. The pain in the pelvis was entirely relieved by x-ray irradiation. In June, the patient returned, complaining of pain in the dorsal spine, which was controlled by irradiation.

In this case of Hodgkin's disease, the patient presented osteoblastic lesions in the pelvis and the upper femora. The diagnosis would have been difficult, if no pathological tissue could have been removed.

We have seen more osteoblastic metastatic lesions than osteoclastic metastatic lesions. The unusual feature in this case is the extensive bone involvement. It is usually limited to one or perhaps to two sites, as illustrated by the roentgenogram of another case (Fig. 8).

The patient reacted very favorably to small doses of deep x-ray therapy and, as the follow-up roentgenograms show, the osteoblastic changes, particularly those in the pelvis, underwent regression. In addition, the periostitis noted along the ilia and left femur made the diagnostic problem slightly more difficult, for this same reaction has been frequently associated with other bone lesions.

CASE 4. E. H., white, male, aged seventy-six, a foreman. (Registry of Bone Sarcoma, No. 1847.)

The patient was admitted to the Nassau County Tumor Clinic on December 28, 1934, with a history of pain in the left arm of six months' duration. Two months before admission, the pain had become so severe and constant that the patient could not sleep. The patient stated that he had been unable to use his arm for three weeks and that for two weeks there had been a swelling in the middle third of the left arm.

FIG. 8

X-ray of spine, showing solitary metastatic lesion.

FIG. 9

Case 4. X-ray of the left humerus, December 20, 1934, showing central destructive lesion in the shaft of the humerus.

FIG. 10

Case 4. X-ray of the left humerus, February 5, 1935, showing progression with destruction of the cortex and extensive soft-tissue invasion after radiotherapy.

The physical examination was negative, except for the local findings in the left shoulder. Motion of the left elbow was limited by pain, and the arm was held fixed at the side. There was a swelling of the middle third of the left arm, that was soft, semifluctuant, and extremely painful and tender. The shaft of the bone was enlarged. A pathological fracture was present.

The Wassermann and urine tests were negative. Roentgenographic examination of the left humerus showed an area of destruction in the middle third, involving the medullary canal and invading the cortex. Productive bone changes were seen in the cortex surrounding the tumor.

An aspiration biopsy was done on January 5, 1935, and the pathological report was metastatic adenocarcinoma. The kidney was the most probable origin.

In view of the patient's age, radiotherapy to the humerus was instituted. Pain in the arm increased in severity with the increase in swelling, and a disarticulation of the left humerus was done on February 11, 1935. In May, pain developed in the chest and the patient brought up blood-tinged sputum. The liver was enlarged and a nodule was palpable. There was a moderately severe jaundice. The patient had lost a large amount of weight and complained bitterly of pain in the right flank. He gradually failed and died on May 30, 1935. No autopsy was permitted.

This patient presented a rapidly growing solitary tumor of the humerus, which was thought to be a primary osteogenic sarcoma. The pathological report of metastatic adenocarcinoma could not be proved, because of the lack of an autopsy. An exhaustive search was made for a primary lesion, with negative results.

A solitary metastatic lesion in this location is exceedingly rare. The

FIG. 11

Case 5. X-ray, January 22, 1935, showing multiple destructive lesions of the pelvis and femora.

tumor was expanding the shaft and acted in its course very much like a primary lesion. The only point against diagnosing this tumor as a sarcoma was the age of the patient.

CASE 5. M. Y., female, adult, aged fifty-three, a housewife.

The patient was first seen at the Nassau County Tumor Clinic on November 21, 1933. She had had a normal menopause thirteen years previously. For three months prior to admission, she had had rather severe flowing at monthly intervals. She had been bedridden for three weeks because of the bleeding.

Physical examination showed an obese adult in good condition. The examination was negative except for stenosis of the vaginal canal. The cervix was involved by an ulcerated bleeding tumor.

Biopsy of the cervix showed plexiform epidermoid carcinoma. Deep x-ray therapy was given, followed by a cervix tandem of radium. Ten months later, there was no evidence of disease in the cervix or the parametria. On October 8, 1934, the patient struck her right shin against a chair. The foot then became swollen and tender. Pain increased. There was tenderness of the entire right leg with slight oedema. Crepitation was present.

X-ray of the right leg showed irregularity in the trabecular structure of the upper third of the tibia, extending down the shaft. There was marked loss of bone density and just below the tibial tubercle the cortex appeared to be entirely destroyed. There was a fracture through the junction of the upper and middle thirds. There were also metastatic lesions, of the osteolytic type, to the skull, spine, and pelvis. Biopsy of the right tibia, on October 10, 1934, showed metastatic epidermoid carcinoma. Radiotherapy to the upper two-thirds of the right tibia was given at this time with some improvement. Four months later pulmonary metastases developed, and the patient died on February 24, 1935.

FIG. 12

Case 5. X-ray of tibia, October 8, 1934, showing metastatic carcinoma of the tibia with pathological fracture.

This case is of interest because of the presence of generalized bone metastases of a carcinoma of the cervix. As far as we know, no metastatic bone lesion in the tibia from the cervix has ever been reported.

CASE 6. C. S., white, male, aged forty-four, a mechanic. (Registry of Bone Sarcoma, No. 1846.)

The patient was seen in the Nassau County Tumor Clinic on November 6, 1934. He had had pain in the right shoulder, with limited motion, for two months. The pain had become worse in spite of rest. Three weeks before admission, a swelling had developed, and the pain had increased. The patient was unable to work.

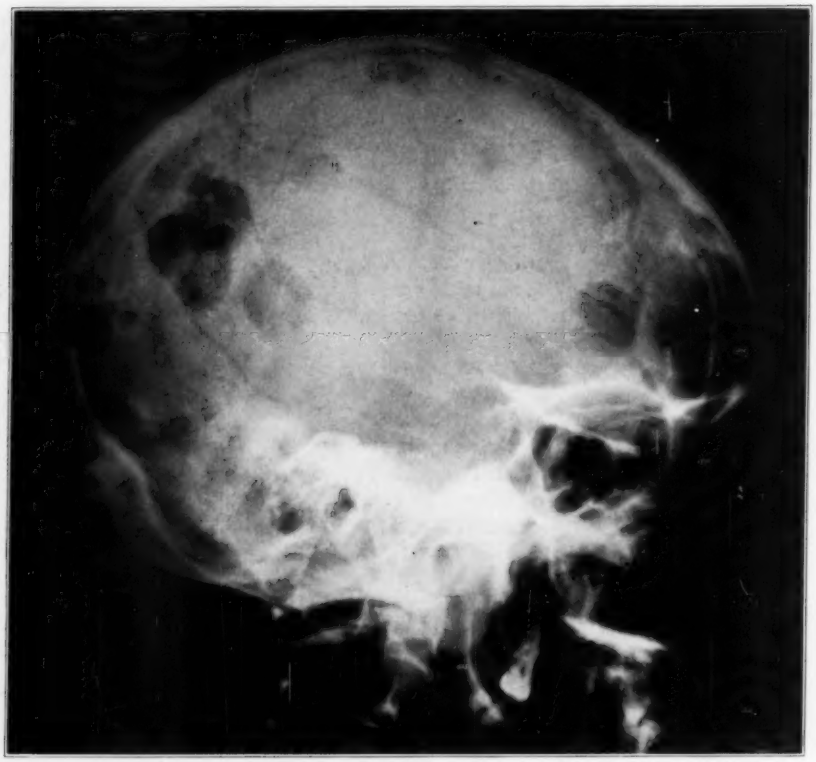

FIG. 13

Case 5. X-ray of skull, January 22, 1935, showing extensive metastatic lesions.

Physical examination was negative, except for a swelling of the right shoulder, which extended beneath the pectoral muscle. There was a dense, firm mass, the size of a large grapefruit, in the region of the head of the humerus. All motions were painful and limited. The grip was weak.

Roentgenographic examination of the right shoulder revealed a large, expanding, destructive tumor in the upper end of the shaft of the humerus. The osseous destruction was almost total. Some osseous production, external to the limits of the bone, was seen in the soft tissue. The appearance was typical of osteogenic sarcoma of the osteolytic type.

The Wassermann and urine tests were negative. Secondary anaemia was present.

An interscapular thoracic amputation was done on November 12, 1934. The diagnosis of the amputated specimen was telangiectatic osteolytic sarcoma.

Roentgenograms of the chest, on December 10, 1934, showed pulmonary metastases. Radiotherapy was instituted on December 12, 1934. Roentgenographic examination of the chest, on December 18, 1934, showed a definite metastatic nodule in the right upper lobe and right lower lobe and small nodules in the left lower lobe.

The patient's condition grew worse, and he died on March 25, 1935.

In this case, the nature of the lesion was discovered late in its course and, therefore, lung metastases were to be expected and were probably present at the time of operation which was necessary to relieve pain.

In this type of rapidly growing tumor, it is imperative that an early diagnosis be made, if any hope is to be expected from surgery.

CONCLUSIONS

Metastatic or primary bone tumors frequently offer difficult problems for diagnosis.

Subjective symptoms may be present for a long time before positive x-ray findings are obtained.

In cases of suspected metastatic bone lesions, radiation therapy should be given for relief of pain, even with negative roentgenograms.

Other findings from the cases studied are as follows:

FIG. 14

Case 6. X-ray of the right shoulder, November 6, 1934, showing an extensive osteolytic lesion of the humerus.

Case 1: There is apparently no definite time limit for bone metastases to follow carcinoma of the breast, even after radical surgery. This is another example of how little faith we can place in our so called five-year cure for cancer. Occasionally, generalized metastatic carcinoma may be confused with our growing knowledge of hyperparathyroidism.

Case 2: In primary neoplasms of the pelvis, pain is radiated to one or both knees without early physical signs. Later, contractures develop and the roentgenographic findings become manifest. This has been true in our two cases of malignant pelvic tumors and may be of help in diagnosis.

Case 3: Alleviation of pain is the important treatment for Hodgkin's disease, particularly when bone is involved, and x-ray therapy plays its part here. Periostitis in bone lesions frequently confounds the diagnosis instead of aiding in its clarification.

Case 4: This case represents a tumor which gives all the clinical evidence of being primary, but pathologically is proved to be of secondary origin. It is well recognized that small undiagnosable primary lesions frequently exist and the only evidence is their secondary manifestations.

Case 5: This is a case of proved epidermoid carcinoma of the cervix, which was apparently cured by radium and x-ray therapy nine months after admission, as far as the original lesion was concerned. Yet, within

fourteen months of the first admission, the patient died of extensive generalized metastatic lesions, some of which were unusually located.

Case 6: Telangiectatic sarcoma is a rapidly growing and fatal form of bone malignancy. Early radical surgery is the patient's only salvation. Technically perfect roentgenograms of the chest are of the utmost importance in ruling out metastases.

A GUIDE FOR THE PARHAM BAND

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Difficulty is usually experienced by the surgeon in placing a Parham band about the shaft of a fractured bone. Since the author has failed to discover on the market a suitable guide for the Parham band, he has devised the instrument illustrated below, which he has found useful in the treatment of fractures.

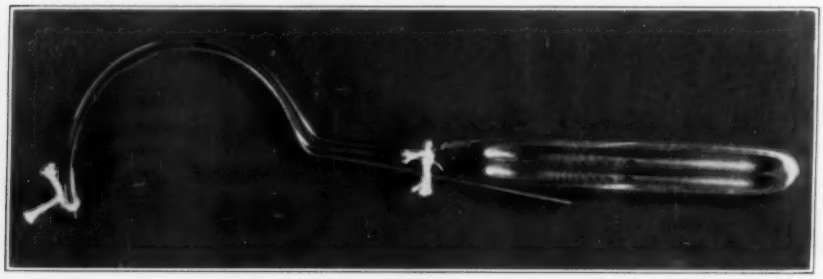

FIG. 1

The instrument is simply a modified aneurysm needle. The surface along the lesser curvature of the arc is grooved to contain the band, which is secured through a perforation at the tip by a catgut ligature. The band may be similarly fixed at the base of the handle. After insertion of the band and instrument about the shaft, the catgut ligatures are removed, the band is held in place, and the guide is withdrawn.

COMPOUND CYSTIC BURSITIS OF THE KNEE JOINT

BY L. E. SNODGRASS, M.D., PHILADELPHIA, PENNSYLVANIA

The following case is presented because of its unusual occurrence.

M. S., a white male, aged nineteen years, entered the surgical dispensary of The Philadelphia Orthopaedic Hospital on Dr. Gill's Service on June 25, 1935, complaining of painless swelling about the right knee. Three years before, while carrying a heavy bag of sugar, he had fallen into the sitting position with his right leg under him, sustaining a twist of the knee associated with swelling. The greater part of this swelling lasted about one week. For the past year, the residual swelling had increased.

Examination of the right knee showed a stable joint, with full range of painless motion. There was a moderate cystic suprapatellar bursitis with some ballottement of the patella. Over the medial portion of the gastrocnemius muscle, there was found a cystic swelling as large as a man's fist. On flexion of the knee with some pressure with his hands, the patient could force this fluid into the suprapatellar bursa. On extension, with pressure over the suprapatellar bursa, he could again distend the lower sac. A diagnosis of compound cystic bursitis communicating through the knee joint was made, and the patient was operated upon on July 1, 1935.

Under general anaesthesia, the lower swelling was incised through a posterior medial incision, and the usual cystic fluid escaped. Suprapatellar pressure greatly increased the force of the escaping fluid. The sac wall was thicker than that of the average cystic bursa and was in intimate contact with the under surface of the deep fascia of the leg on one side and with the belly of the gastrocnemius on the other. It was dissected free in its entirety in a retrograde manner, the sac becoming progressively smaller in diameter until the neck passed around the medial head of the gastrocnemius and joined the synovia of the knee joint. As the neck of the sac wound about the head of the gastrocnemius, it gave off a diverticulum, approximately one inch in length, which lay in the popliteal space. The neck was ligated and cut close to the joint; the stump was touched with full-strength iodine; and the wound was closed without drainage. An incision was then made over the suprapatellar bursa and most of this sac was extirpated.

FIG. 1 *

Examination on October 8, 1935, revealed normal function in the knee joint with absence of fluid.

Davis states that the suprapatellar bursa communicates with the knee joint in eight out of ten cases. He also states that, of the posterior bursae, the one under the inner head of the gastrocnemius is the most important and often communicates with the joint. The popliteal ganglion usually originates in this bursa.

In the patient whose case is reported, both the suprapatellar bursa and the medial posterior bursa communicated with the knee joint, permitting the free passage of fluid from one to the other through the joint.

DAVIS, G. G.: Applied Anatomy. The Construction of the Human Body Considered in Relation to Its Functions, Diseases, and Injuries. Ed. 5, pp. 538–539. Philadelphia, J. B. Lippincott Co., 1918.

* For this photograph, the author is indebted to Dr. Irvin Stein.

OSTEOCHONDRITIS DISSECANS OF THE PATELLA

A Case Report

BY CHARLES ROMBOLD, M.D., F.A.C.S., WICHITA, KANSAS

Having found no recent case reports of osteochondritis dissecans of the patella, the writer presents the following case:

J. F., a male, aged twenty-four years, had been active in high school and college athletics for six years with a symptomless left knee. Approximately eighteen months before examination and during the basket-ball season, without any specific injury, some ache and lameness were noted in the knee. This ache was indefinite and was not associated with any particular position or movement, but was severe enough to cause the patient to seek relief. The patient obtained relief from pain by wearing an elastic knee brace during play. Pain was precipitated when the brace was removed.

FIG. 1

Lateral view of the patella, showing the osteochondritic focus.

A few months after the initial appearance of the pain, the patient was forced to stop broad jumping principally because of the weakness in the knee. The patient continued running the quarter mile, however. The symptoms of pain and weakness increased in severity during the second basket-ball and track season, until they became severe enough to cause the patient to seek surgical relief. The pain was always diffuse with possibly some localization on the articular surface of the patella. The aching in the knee was increased with long flexion of the joint and was relieved by extension of the knee.

The general physical examination revealed no pathology as possible foci of infection nor glandular disturbance. The only positive findings in the knee were a slight increase in the joint fluid, which showed normal cytology on aspiration, and pain and crepitation when the lower pole of the patella was apposed to the femur. There was atrophy of the left thigh amounting to three-quarters of an inch.

Under local anaesthesia, an arthrotomy of the knee was performed. There was no unusual amount of fluid in the knee; the synovia was neither injected nor apparently abnormal. The menisci were firmly attached and their free edges were not abnormal. The crucial ligaments were competent. The articular cartilage of the femur and tibia was smooth, glistening, and of normal color. There was a band of fine longitudinal striations, about one centimeter in width and three centimeters in length, in the cartilage of the intercondylar notch. These striations represented the area of contact made with the femur by a defect in the patellar cartilage. There was a defect in the cartilage lying equidistant from the lateral and medial surfaces of the patella and in the lower pole. This defect was approximately round and about one and one-half centimeters in diameter. The circumference of the defect was marked by a yellowish, dull,

raised border of the articular cartilage, about one millimeter in width. Within the circumference of the defect, the cartilage was somewhat dull, but of about the same color as the balance of the articular cartilage. By placing a probe in the center of the defect and moving the probe, motion could be detected between the patella and the defect.

After the raised border of the defect had been incised throughout its circumference, the plug of cartilage and bone was lifted from its bed. There was no attachment between the fragment removed and the patella except the elevated discolored circumference of articular cartilage. There was no bleeding from the base of the defect when the plug was removed. Firm bone, without any apparent covering of soft tissue, lay in the base of the defect.

The pathological report by Dr. C. A. Hellwig was as follows:

"The specimen measures two by one and two-tenths centimeters. One-half is eight millimeters thick; the other half, only two millimeters thick. The articular or cartilaginous surface of the specimen is glistening, smooth, bluish-white, while the patellar or bony surface is irregular, mulberrylike and of brownish color. The cartilage represents about two-thirds of the thickness of the specimen; the balance is osseous.

"The hyaline cartilage shows no evidence of degeneration. The matrix is homogeneous; the cells are perpendicular, well stained, and of uniform size. The deep layer of the cartilaginous portion is calcified and spongy bone is adjacent.

"The bone trabeculae have normal form, although no stained cells are found. The intertrabecular tissue is without blood vessels. Rows of osteoblasts are found lining several bone trabeculae. The intertrabecular tissue is replaced for a short distance from the entire osseous margin by fibrocartilage. This fibrocartilage is connected with, and seems to originate from, the hyaline cartilage covering the articular surface of the specimen.

"Diagnosis: Loose body, consisting of living hyaline cartilage, fibrocartilage, and necrotic bone."

FIG. 2

Longitudinal view of the patella, showing the osteochondritic focus.

This osteochondritis dissecans process in the patella seems to be identical with that process which occurs in the medial condyle of the femur. The subjective symptomatology, which is vague, is similar in the patella and in the femur. The gross appearance of the two lesions is identical and the microscopic pathology is exactly the same.

ACUTE HEMATOGENOUS OSTEOMYELITIS OF THE SCAPULA (ACROMION PROCESS)

BY ROBERT D. FAIRCHILD, M.D., ROCHESTER, MINNESOTA

From the Orthopaedic Department, Receiving Hospital, Detroit, Michigan

Up to 1926, forty-six cases of acute hematogenous osteomyelitis of the scapula had been reported [1]. Since that time, the only instance of this condition found in the literature is that reported by Williams [2] in 1927.

The following case is reported because it is unique, in that the infection primarily involved the acromion process of the scapula, and there was an interesting sequela.

J. T. (P. 1925), a white male, aged eighteen, was admitted to the Receiving Hospital on February 3, 1935, with a history of pain and disability in the right shoulder of two days' duration. There was no history of injury to the shoulder nor of previous bone infection. Some redness and induration, localized to the acromion process of the right scapula, were noted. There was acute tenderness over the point of the shoulder and pain on moderate abduction and circumduction of the humerus. No active foci of infection could be demonstrated either from the history or on physical examination. Except for the shoulder, the physical examination was essentially negative. The temperature on admission was 105 degrees by mouth.

There were 10,500 leukocytes and 4,260,000 erythrocytes per cubic millimeter of blood. There were 12.2 grams of hemoglobin per hundred cubic centimeters of blood. In the blood smear there were 49 filamentous and 40 non-filamentous neutrophiles and 11 lymphocytes. There were 3 leukocytes per high-power field in the centrifuged specimen of urine. The urine was otherwise negative and of low specific gravity (1.003). The Kline test for syphilis was negative.

On the day after admission, a linear incision was made over the spine of the right scapula, extending laterally to a point below the acromion process. Purulent material was revealed overlying the acromion process close to the bone and near the acromioclavicular joint. Drill holes were made into the acromion process and into the lateral end of the clavicle, because of the possibility of clavicular involvement, and the wound was packed with vaselin gauze. A culture of the purulent material showed staphylococcus aureus.

The temperature dropped to 100 degrees two days later, but rose again to 104 degrees on the fifth postoperative day and continued to be high and septic in type. A blood culture, taken on the fifth postoperative day, was incubated for five days and revealed no growth.

A roentgenogram of the right shoulder, taken on the tenth day after operation, showed slight destruction of the acromion process involving the metaphyseal portion. The clavicle did not appear to be involved.

On the eleventh day, an aeroplane spica was applied to preserve abduction of the humerus, and induration was noted in the midline high up in the intrascapular area. With the aid of moist compresses, this induration progressed to swelling and fluctuation. A week later, the aeroplane spica was removed and the acromion process and spine of the scapula were explored. The previous operative wound communicated with a large abscess in the intrascapular region in the midline. The abscess was incised over its dependent portion and drained of at least ten ounces of purulent material. The patient's temperature gradually returned to normal and remained so until discharge, fifty-four days after admission.

Roentgenographic examination of the right shoulder just before discharge showed evidence of osteomyelitis of the upper surface of the clavicle. This appeared to involve the acromioclavicular articulation. The roentgenogram did not include the acromion process of the scapula. X-rays of the dorsal and cervical spines on two occasions showed no evidence of osteomyelitis.

The patient came to the Out-Patient Department for dressings three times a week and the wound over the shoulder gradually cleared up. A roentgenogram of the shoulder, taken on May 14, 1935, showed irregularity of the upper margin of the acromion with some new bone formation. No change in the distal end of the clavicle was noted at this time.

A sinus developed in the posterior midline in the region of the spine of the second thoracic vertebra. This was injected with an opaque mixture and stereoscopic roentgenograms showed a dilated sinus tract lying over the second thoracic vertebra and extending from right to left. The tract had no apparent connection with the vertebrae, and no bone pathology could be demonstrated in this region.

On June 22, 1935, the sinus was opened widely, curetted, and packed. A sequestrum, the shape of a vertebral spinous process and two centimeters long, was removed during this procedure.

The wound over the shoulder has completely healed and the wound in the posterior midline has filled with healthy granulations. At present, the prognosis for full recovery is excellent.

SUMMARY

An interesting sequela of this case of acute hematogenous osteomyelitis of the scapula, localized to the acromion process, was the development of a contiguous abscess over the upper dorsal vertebrae and the subsequent removal of a sequestrum, the shape of a vertebral spinous process. The latter was undiagnosed roentgenographically.

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A FORM OF BALANCED TRACTION

A Modification of Russell Traction

BY A. MARIANS, M.D., BROOKLYN, NEW YORK

From the Orthopaedic Service, Kings County Hospital, Brooklyn*

In the treatment of cases requiring traction to the lower extremity, it has been the author's practice to use Russell's method of producing traction. Since this method necessitates constant observation and adjustment, the author has devised the following modification which insures maintenance of the extremity in a fixed position.

As shown by Figure 1, traction is applied in the same manner as in the Russell method, except that a pulley is added at *A*, making five pulleys instead of four. The rope starts at a fixed point on the overhead bar and passes through pulleys *A*, *B*, *C*, *D*, and *E*, successively. The section of rope from the fixed point to pulley *B* forms a vertical line; the section of rope from pulleys *C* to *E* forms a horizontal line. The position of the femur is determined by the level at which pulleys *C* and *E* are

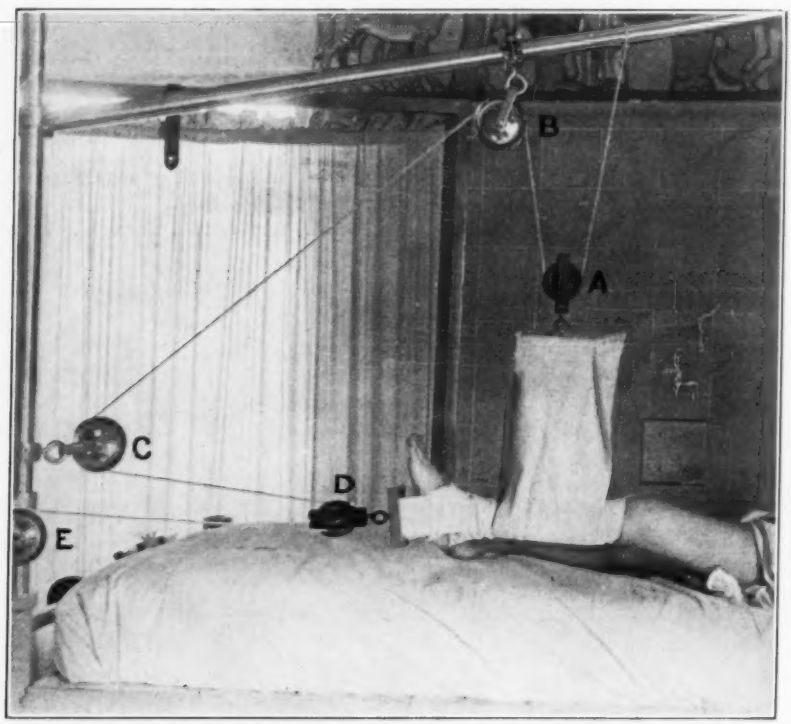

FIG. 1

* J. B. L'Episcopo, M.D., Director.

placed. The higher these are placed, the greater is the angle of hip flexion. The amount of weight necessary is determined by the weight of the extremity and the distance from the bed at which the leg is to be maintained. Enough weight is used to balance the extremity, seven pounds usually being sufficient for an adult.

Figure 2 illustrates the mechanism of producing traction by this method in the case of a fractured femur. The resultant of the equal forces *V* and *H* is *R 1*. However, the partial weight of the limb, *G*, is a variable, depending upon the height at which the limb is fixed. The resolution of *R 1* and *G* equals *R 2*. Furthermore, *R 2* is to a great extent neutralized by the resistance of the femur, *F*, producing the final resultant, *X*, whose force is problematic and whose direction is that of the distal portion of the femur. In cases where the fragments are pulled apart, *X* must be a positive quantity; where overriding persists, *X* is negative; where a perfect result is obtained, *X* is zero.

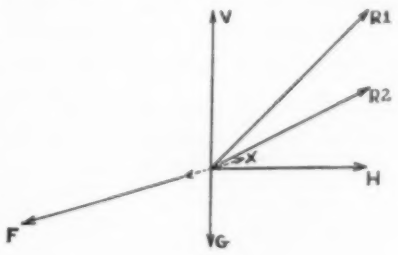

FIG. 2

This traction has been successfully applied to reduce fractured femora, flexion and adduction deformities of the hip, and flexion deformities of the knee, and to relieve referred pain in lumbosacral and sacroiliac lesions.

A USEFUL AMPUTATION GUARD

BY FRANCIS M. FINDLAY, M.D., SANTA BARBARA, CALIFORNIA

It is very often difficult to retract the skin and muscles properly when performing a thigh amputation in an obese individual or in one with heavy thick muscles. Unless the soft tissues are adequately protected, the muscles will be traumatized by the saw and will interfere with cutting of the bone. The skin flaps must be firmly retracted or they will invert and contaminate the freshly cut surface of the wound. Trauma always results in tissue necrosis and provides a ready field for bacterial growth. With the large number of amputations now being done in older diabetics and arteriosclerotics, every precaution must be taken to avoid tissue necrosis and to prevent bacterial contamination of the wound. Meticulous attention to every detail of technique is essential if primary healing is to be the rule in every amputation stump.

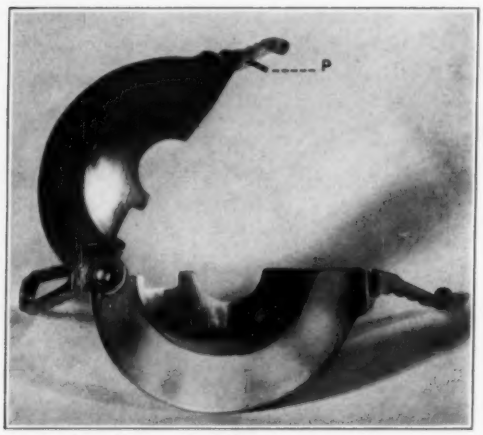

FIG. 1

Guard open, showing: holes for two bones; *P*, pin for locking handles which hold the disc together.

FIG. 2

Guard closed, showing handles locked in position.

Long strips of sterile gauze or towels, held by an assistant, are now commonly used to retract muscle flaps. This method is unsatisfactory, for the cloth frequently becomes caught in the teeth of the saw and the towels slip off at the critical moment, allowing the skin surface to come in contact with the muscles and bone. The guard illustrated in this paper is one that the author procured in Germany several years ago, and it has been found very useful. It is described in the hope that it may be of value to others.

This guard, a hinged metal disc with a slightly convex surface, is seven inches in

diameter and has two handles. The disc has two openings: the central opening is one and one-half inches in diameter and will readily admit the femur; the second opening can be used to advantage for amputations through the lower leg or forearm.

After the skin incision has been made, Allis clamps are applied to the skin flaps, which are held back while the deeper soft tissues are divided and the bone is exposed. The open disc is then applied and the blades are closed and locked about the femur. The assistant, while resting his forearms on either side of the thigh to steady the leg, exerts gentle traction upon the handles of the disc, which exposes the femur for the surgeon. The bone can now be severed without fear of catching gauze or muscle in the teeth of the saw. After the limb has been amputated, the guard is removed and the stump is closed in the usual manner.

A HIP BRACE

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

In two recent cases of congenital dislocation of both hips in small children, open reduction was easily accomplished and was well maintained by the application of a double plaster hip spica. Following removal of the plaster spica after three months, one hip subluxated in each case. The apparent cause of the subluxation was a too rapid reduction of the position of marked abduction maintained following operation.

In order gradually to reduce the amount of abduction following removal of the plaster in such cases, a light brace (Fig. 1) has been devised and successfully used in a third case (Fig. 2). Gradual reduction of the abducted position can by secured by bending the distal cross bar upward. Meanwhile, inward pressure on the upper portion of the thighs can be obtained through the upper brace straps by gradually decreasing the size of the perineal loop at the same time that the distal cross bar is being bent upward.

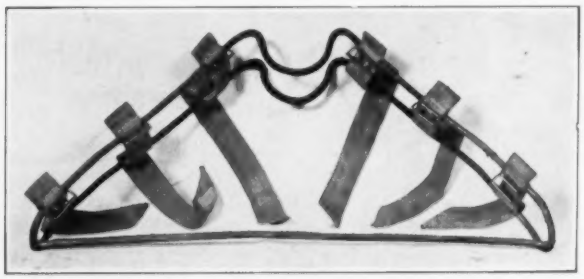

FIG. 1

FIG. 2

This brace embodies the principles laid down by Putti and Jaeger in the use of triangular braces and pads for closed reduction in congenital dislocation of the hip in much younger infants. The author believes that this simple and inexpen-

sive apparatus will aid in the gradual post-operative mobilization of the congenitally disslocated hip in both unilateral and bilateral cases, and will lessen the number of embarrassing cases in which the hip subluxates following removal of the plaster.

ADJUSTABLE SHOULDER STRAP FOR POSTOPERATIVE TORTICOLLIS CAST

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS

Postoperative casts, applied to stabilize the head and neck following operations for the correction of torticollis, soon lose their efficiency as a means of stretching muscles and fasciae not divided surgically. In order to continue a corrective and stretching force, an adjustable padded sling is placed over the acromioclavicular area on the side which has been operated upon. The ends of the webbing strap are carried through holes in front and back of the cast and are buckled over the shoulder area. Increase of the tension of the sling depresses the shoulder, stretching all soft tissues on that side of the neck.

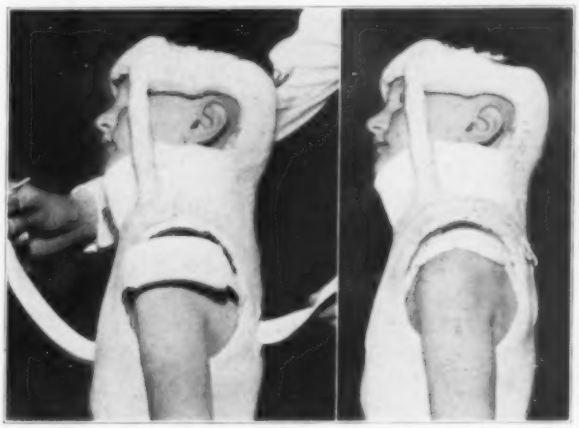

FIG. 1

GOUT: AN UNUSUAL MANIFESTATION IN A STUMP

BY W. E. KENDALL, M.D., F.A.C.P., H. C. FORTNER, M.D., AND
S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

A reasonable search of the literature reveals no report referable to symptomatic gout in a stump. In the following case, a painful stump, due to pressure of minute uric-acid crystals against the nerve endings, had caused continuance of pain from 1932 to 1935. When systemic treatment for gout was instituted symptoms were relieved.

E. D., a white male, aged thirty-four, a farmer, was first admitted in 1930 for treatment of epithelioma of the left knee, with ulceration and partial fibrous ankylosis.

The patient had had the usual diseases of childhood. In 1920, a fracture of the left patella had been reduced by the open method. Thirty-one operations on the left knee had been performed during the period from 1920–1927. These operations had consisted of excision and cauterization of the ulcers. The family history was essentially negative.

Physical examination on March 13, 1930 was negative except for obesity and multiple cicatrices about the left knee with ulceration. On March 18, 1930, the ulcer on the lateral side of the knee was excised and the denuded area was covered by a pedicle skin graft, followed by irradiation for 792 millicurie hours. The patient was not cooperative and was not seen again until July 1932, at which time the lesion had increased in size. The left thigh was amputated and the stump healed satisfactorily. A prosthetic appliance was provided.

In September 1932, the patient returned, complaining of a painful stump. The left sciatic nerve was injected with alcohol on two occasions without relief; therefore, reampu-

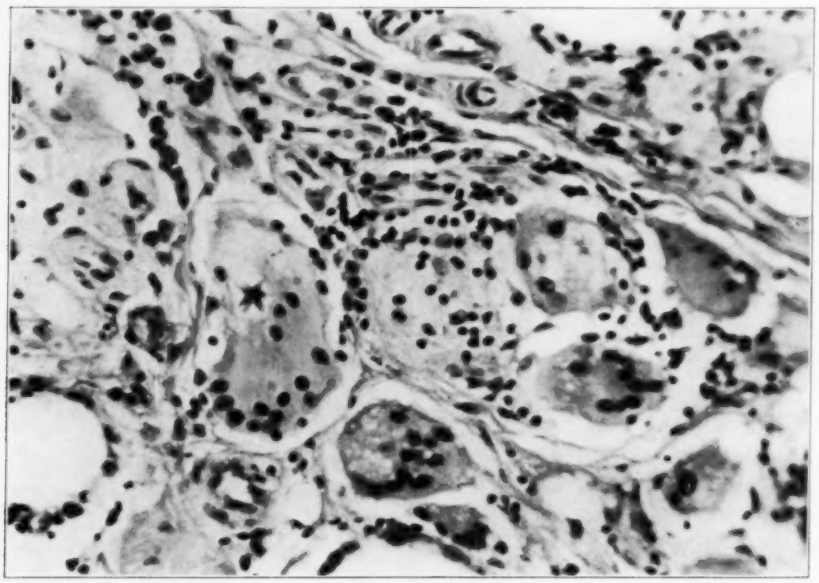

FIG. 1

Section from stump showing foreign-body reaction in the giant cells, within which uric-acid crystals are seen.

tation for exostoses and neuromata was done. The incision healed promptly and the patient was discharged in a few days, free from symptoms. Shortly after discharge, the stump again became so painful that the artificial limb could not be worn.

In May 1935, the patient was readmitted because of the painful stump. On examination, the amputation scar was found to be well healed. On the inner aspect of the scar, there was a nodule, small in size, but very tender. The nodule measured two centimeters in diameter and was firm. A diagnosis of recurrent neuroma of the left thigh was made. The mass was dissected and found to contain no nerve tissue.

Roentgenographic examination revealed a small island of abnormal density over the end of the stump, due to injection of a foreign substance or to calcified sequestra.

Analysis of the blood showed:

Red blood corpuscles—5,400,000
White blood corpuscles—10,000
Hemoglobin—95 per cent.
Uric acid—7.2 milligrams per 100 cubic centimeters.

The Wassermann and Kahn tests were negative.

Histological examination of the specimen from the stump (Slide 10,907), removed on May 13, 1935, showed an abundance of scar-tissue formation with heavy infiltration by round cells in places. In some areas, foreign-body reaction in the giant cells was evident. Within some of these cells, uric-acid crystals were seen. Most of these crystals lay wholly within or at the margin of the vacuoles. Uric-acid crystals are visible, as illustrated, within giant cells, whose walls protect the crystals from dissolution by the fixing process. Crystals without the giant cells could not be visualized, probably due to their destruction by fixation.

A diagnosis of gout was made and the usual medical treatment was prescribed, followed by relief of symptoms.

SUMMARY

In this unusual case of a painful stump, due to gout, the etiology was finally established by the following findings:

1. The blood uric acid was 7.2 milligrams per 100 cubic centimeters (twice the upper limit of normal);
2. Section from the stump revealed uric-acid crystals in giant cells;
3. Systemic treatment caused relief of symptoms.

COLON-BACILLUS OSTEOMYELITIS

BY MORRIS B. COOPERMAN, M.D., AND GOTTLIEB S. LEVENTHAL, M.D.,
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Osteomyelitis resulting from infection by colon bacillus is quite rare, judging from the fact that there are only eight cases reported in the literature. It is quite possible that others may have occurred but either have not been recognized or have not been recorded.

M. B., aged forty-nine, a veterinary surgeon, who had always been in good health, became ill on July 21, 1927, with symptoms and signs of trouble in the right upper quadrant of the abdomen. Roentgenograms on three occasions revealed an elevated and fixed right diaphragm. Bacillus coli and staphylococcus aureus were cultured from duodenal drainage. Febrile temperature subsided by lysis in eight days. On the twenty-eighth day of illness, the patient had an unexplainable rise of temperature. The fever declined gradually and the temperature was normal five and a half weeks after the onset of the illness. A roentgenogram, taken on August 25, 1927, revealed that the right diaphragm moved freely.

Early in September, signs and symptoms of an abscess developed on the lateral aspect of the left thigh at the junction of the lower and middle thirds. The white blood count was 15,000; polymorphonuclear leukocytes, 62. A large subperiosteal abscess was found and drained on September 14, 1927, but no culture of the pus was made. A roentgenogram revealed an extensive osteomyelitis, extending from below the greater trochanter to the lower third of the femur.

On October 7, the patient developed an abscess, containing a small quantity of pus in the left occipital region beneath the pericranium. The bone appeared sound and the wound healed. Culture was sterile.

One week later, the patient developed an abscess in the upper third of the left forearm. At operation, the periosteum of the ulna was found to be thickened, but there was no free pus. A smear taken from the wound revealed the presence of a gram-negative bacillus in pure culture. A sinus in the left thigh persisted.

In November 1928, a pus pocket developed in the left thigh, which was drained. The sinus continued to drain for the next year, and, except for the development of small subperiosteal abscesses on the anterior aspect of both tibiae, which were opened by the family physician, the patient felt quite well.

In November 1929, another subperiosteal abscess in the left thigh was drained. A roentgenogram revealed the middle two-thirds of the shaft of the femur to be considerably increased in circumference, due to periosteal proliferation and new bone formation. The bone was unusually dense and sclerotic and there was no destructive lesion in the marrow cavity. A small subperiosteal abscess of the right tibia was incised and the wound healed in two months. Culture from the wound showed the presence of a staphylococcus aureus and a gram-negative bacillus identified as bacillus coli. The gallbladder failed to fill on cholecystography. The drainage of the left thigh persisted and, except for a superficial abscess of the left thigh and another of the left leg, the patient felt quite well for the next five years.

On January 1, 1935, the patient injured the left leg just below the knee. Pain and swelling followed and an incision was made by the family physician for a suspected abscess. Although some pus was evacuated, the swelling and pain became worse and the left knee became swollen and hot.

Blood examination showed:

White blood corpuscles—22,900 per cubic millimeter
Polymorphonuclear leukocytes — 89 per cent.
Urea nitrogen — 18 milligrams per 100 cubic centimeters
Blood sugar—161 milligrams per 100 cubic centimeters

A roentgenogram revealed an acute osteomyelitis of the upper end of the tibia.

At operation, there was a gush of canary-yellow pus from beneath the periosteum in the upper fifth of the tibia. The necrotic bone was osteotomized. On aspiration, pus was found in the knee, necessitating parapatellar incisions for drainage. Culture from the pus revealed the presence of a pure culture of bacillus coli.

The patient continued to become progressively worse, the osteomyelitis of the tibia progressed, and further saucerization of the left tibia was necessary. The incisions of the knee were also enlarged to permit better drainage.

On January 22, 1935, the patient developed pain and tenderness just below the right tibial tubercle. At operation, the periosteum was found to be thickened. Several drill holes were made into the bone, and, after a few moments, yellow pus welled up under considerable pressure. Culture from this wound showed the presence of bacillus coli in pure culture.

Blood culture, taken on January 23, 1935, also showed the presence of bacillus coli. The patient developed bronchopneumonia and marked tympanites. The blood sugar varied between 160 and 440 milligrams per 100 cubic centimeters and, on two occasions, there was sugar in the urine. The patient became very toxic and delirious, and died on January 27, 1935.

A very interesting feature of this case is the fact that all the foci of involvement except the last were subperiosteal, with marked periosteal new bone formation and no tendency to medullary involvement. The late Dr. John B. Deaver, who had treated this patient, felt that the osteomyelitis of the femur was secondary to a pathological gallbladder. Although the culture from the ulna was not identified beyond the gram-negative bacillus, in view of what subsequently followed, it is rather safe to assume that it was the colon bacillus. The supposition that the gastro-intestinal tract (gallbladder) could have been the original focus is supported by the fact that seven of the eight cases of colon-bacillus osteomyelitis reported in the literature came on during the course of, or convalescence from, typhoid fever. Wilensky is of the opinion that, except for direct infection, colon-bacillus osteomyelitis is secondary to a lesion in the gastro-intestinal tract through which the colon bacillus gains entrance into the blood stream. Satta cited a case of colon-bacillus osteomyelitis occurring in a compound fracture of the leg in which amputation was necessary in order to save the life of the patient. This is apparently the only reported case resulting from infection introduced from without. Satta noted that the pus was yellowish. Berg, Blumer, and Martina each reported a case with recovery from costal chondritis following typhoid. Charbonnel reported a case following dysentery, in which there was present greenish-yellow pus, marked periosteal thickening, and bone abscess. The patient recovered. Klemm and Arcoleo each reported a case following typhoid, from which both the colon and typhoid bacillus were cultured. Both patients died. Winslow reported a case

of osteomyelitis of the right femur in which the patient recovered with ankylosis of the knee. It is thus seen that cases in which there was secondary infection had a fatal termination, although an amputation was necessary to save the life of one patient without secondary infection.

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A TAUTENING BOLT FOR USE WITH KIRSCHNER WIRE WHEN PLASTER-OF-PARIS CASTS ARE USED IN THE TREATMENT OF FRACTURES

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LINCOLN, NEBRASKA

To overcome the obvious disadvantage of having to incorporate a large bow in plaster for a long period of time, thus making the cast more cumbersome and necessitating the use of a large number of bows, we have devised a tautening bolt which may be used to replace the usual bow after twenty-four to forty-eight hours.

The tautening-bolt assembly consists of an ordinary three-eighths-inch bolt and nut, the bolt being, over-all, five-eighths of an inch in length. Both the bolt and nut are slotted by a wide saw cut to the longitudinal axis of the bolt. A case-hardened machinist's set screw is then placed in the head of the bolt in such a way that, when the slotted bolt is placed on the Kirschner wire, the set screw can be tightened effectively on it. A pressure plate, which is also slotted and about one inch in diameter, is used.

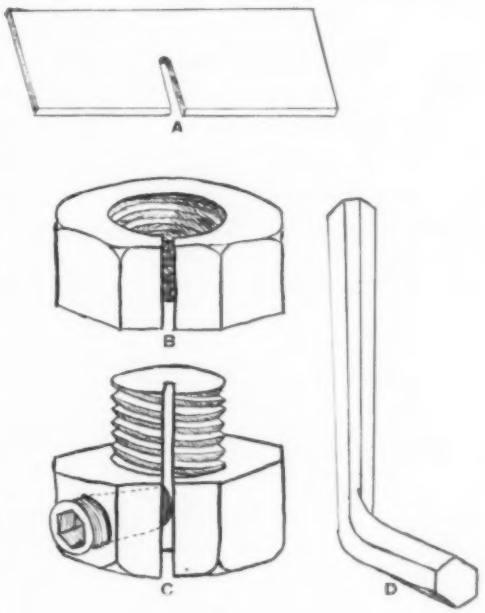

FIG. 1

Tautening-bolt assembly, showing: *A*, pressure plate; *B*, method of slotting; *C*, machinist's set screw; and *D*, wrench.

Technique of Application

The wire is drilled through the bone in the conventional man-

FIG. 2

Tautening bolt in place. The bow has been removed and the ends of the wire have been cut off.

ner and the tautening bow is applied. Suitable traction is applied by the use of the traction apparatus of a fracture table, and the reduction of the fractured fragments is accomplished. Anteroposterior and lateral molded plaster-of-Paris splints are applied and held in place by crêpe-paper bandage. Two four-inch squares of plaster-of-Paris splint are cut to their center and molded closely about the Kirschner wire, one on each side, and the whole is reenforced with several circular bandages. The patient is put to bed and swung under appropriate overhead frames. After forty-eight hours, or when the cast has thoroughly dried, slotted pressure plates and tautening bolts are slipped over the Kirschner wire close to the cast and the set screws are tightened firmly against the wire. By means of two thin wrenches, the nut of each bolt is turned against the pressure plates sufficiently to insure the tautness of the wire. The bow is removed and the ends of the wire are cut off, after which the whole may be covered by several turns of bandage if desired.

AN INEXPENSIVE PORTABLE THERAPEUTIC POOL

BY PHILIP PALEW, M.D., JACKSON HEIGHTS, LONG ISLAND, N. Y.

The many advantages of the underwater treatment in the after-care of patients who have had poliomyelitis need no elucidation at this time.

The lack of available space and, what is still more important, the lack of sufficient funds were responsible for the development of the tank which is described in this report. It has been in continuous use on the Orthopaedic Service of Dr. Arthur Krida at Bellevue Hospital for the past year, with very gratifying results.

A waterproof canvas tank—twenty-four inches deep, six feet long, and four feet wide—is suspended from a frame forty-three inches high. Standard faucets are incorporated into two opposite corners to permit rapid filling and emptying. The frame is constructed of interlocking galvanized pipe which can be taken apart easily. When the tank is not in use, it can be folded so that it occupies very little space. If sufficient space is available, the frame can be made at much less expense by joining the piping permanently with standard steam fittings.

An angulated Bradford frame is suspended from one edge of the frame and rests upon the bottom of the tank. The bottom of the tank is kept rigid by folding boards which are held underneath it by a folding steel framework. In the stationary tank the framework need not be so complicated.

Canvas straps, whose height can be altered, are slung across the head of the tank for the patients to rest their heads upon.

In filling the tank, a standard garden hose is connected to a combina-

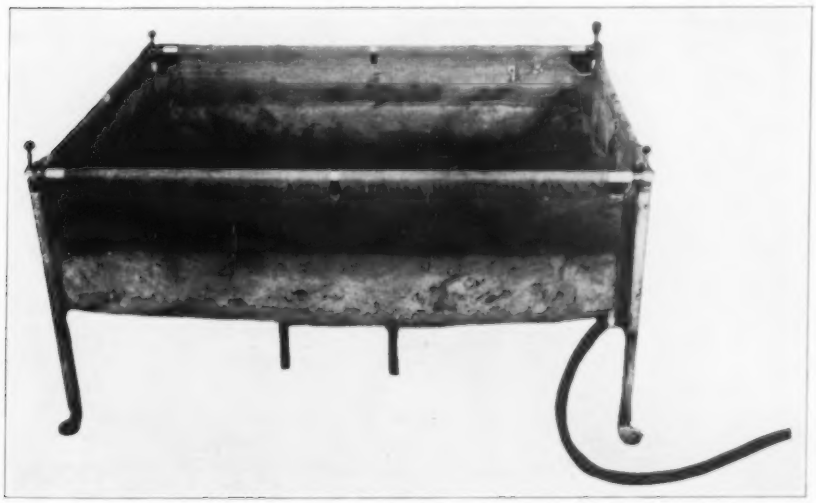

FIG. 1

tion hot and cold-water faucet and water of the desired temperature is permitted to flow into the tank. The water can be sterilized with chlorinated lime. The pool is easily washed with soap and water.

To make the tank more easily portable the legs are supplied with casters. Moving the tank while it is filled is not recommended because of the great weight of the water.

Another advantage of this pool is the fact that the attendant is not forced to soak in water for prolonged periods of time. Protected by a rubber apron, and without uncomfortably stooping over, the attendant can assist the patient in his muscular effort.

Besides its usefulness in the treatment of poliomyelitis, the underwater treatment has been found useful in the limbering up of stiff contracted joints which follow infectious arthritis or prolonged immobilization in casts after reduction of fractures or operative procedures.

News Notes

The orthopaedic world sincerely regrets the loss that has come to it through the death of **Mr. Ernest Muirhead Little.** Mr. Little was a prominent figure in the early days when the solution of the surgical problems was not so well determined, when the position of orthopaedic surgery was not so well established as it is today, and when the pioneers were endeavoring to find their places in the medical and surgical community. These were difficult times in the attempt to establish the recognition of the special departments. In addition to their professional accomplishments, the character and type of these men exerted an important influence in establishing mutual and cordial relations among the members of their community. Mr. Little was an active and prominent member. We may now pay tribute to him for the part which he played in the establishment of the privileges which we at this time enjoy. His sturdiness of character and good judgment helped to guide the work of those pioneers among whom he was prominent. In his passing, we have lost not only an orthopaedic surgeon, but a kindly gentleman of the old school.

Readers of *The Journal* will be interested to know that *"Zeitschrift für Orthopädie und Ihre Grenzgebiete"* is the new name of the official publication of the **Deutsche orthopädische Gesellschaft,** formerly known as the *"Zeitschrift für Orthopädische Chirurgie Einschliesslich der Heilgymnastik und Massage"*. This change became effective with 64. Band, 1. Heft, 1935.

The **American Academy of Orthopaedic Surgeons** will hold its Fourth Annual Convention on January 13, 14, 15, and 16, 1936, at the Hotel Jefferson, St. Louis, Missouri. A large attendance is expected.

Sessions will be held on three mornings and three afternoons. On Monday afternoon there will be a Symposium on Bone Tumors, and on Wednesday afternoon a Symposium on Fractures and Dislocations in and around the Elbow Joint. At each morning session and at the Tuesday afternoon session four twenty-minute papers will be presented, with four five-minute discussions of each paper.

The program has been so planned that at each session will be presented papers from one section of the country, while the discussors for these papers have been selected so as to represent the views of other sections of the country on the essayist's subject. Monday morning's session will be presented by men from the Pacific Coast; Tuesday morning by men of the Middle West; Tuesday afternoon by men from the East Coast; Wednesday morning by members from the South and Southwest.

Each morning session will start at 9:30 o'clock and end at 12:30; each afternoon session will start at 2:00 o'clock and end at 4:30. This will give adequate time each day for the inspection of the Scientific and Commercial exhibits, which will be of unusual interest.

During the morning and afternoon of January 16, an unusually well planned program of diagnostic and operative clinics will be conducted by the leading orthopaedic surgeons of St. Louis.

The **American Society for the Study of Arthritis** held its Seventh Annual Meeting on December 12, 13, and 14, in New York City. The sessions were held in Le Perroquet Suite of The Waldorf-Astoria. A most interesting program had been prepared, including the informal presentation of papers at the afternoon sessions on Thursday and Friday, round-table discussions of arthritic problems on Thursday and Friday mornings, and the annual business meeting of the Society on Saturday morning. On Thursday evening the annual open meeting of the Society was held at the New York Academy of Medicine, and

papers were presented by Dr. Reginald Burbank, New York, N. Y., Dr. Loring T. Swaim, Boston, Massachusetts, and Dr. Martin E. Rehfuss, Philadelphia, Pennsylvania.

The Thirtieth Congress of the **Deutsche orthopädische Gesellschaft** was held in Köln on September 2, 3, and 4, under the presidency of Prof. M. Hackenbroch.

The principal subjects considered at the Congress on the different days were the Interrelation of Structure and Function, Orthopaedic Surgery and Its Relation to Posture, Development of the Body, and Degenerative Changes of Occupation and Age. A number of the members presented papers on each of these subjects, and this presentation was followed by general discussion by the members.

On the third day, the subjects of Arthrodesis and Tenodesis and Coxa Valga were presented and discussed. Numerous papers on other matters of orthopaedic interest were also presented by various members and guests.

On the evening of Monday, September 2, there were demonstrations and illustrations by lantern slides and pictures along the lines of the subjects which had been discussed, as well as on various other subjects.

The 1936 Congress will be held in Königsberg, under the presidency of Prof. Dr. L. Kreuz.

The Congress of the **Czechoslovakian and Jugoslavian Orthopaedic Societies** was held at Brno, September 26, 27, and 28, under the presidency of Prof. Dr. B. Frejka.

The mornings of the first two days were devoted to demonstrations and operations. Among the operations performed at this time were osteotomy for genu valgum, correction of torticollis, resectio sub talo, astragalectomy, and fusion of the spine both for tuberculosis and for lumbosacral arthritis. On the afternoon of September 26, there was a dry clinic, with demonstrations of postoperative cases of these conditions, showing the treatment necessary, particularly in cases of lumbosacral arthritis in which an osteosynthesis had been performed.

The academic program of the Congress was opened on the afternoon of September 27 by the President. The principal subject was Low-Back Pain. Dr. Gradojevič, as the first speaker, presented a paper giving a summary of the different causes of pain in the lumbar region and emphasizing the rôle played by static defects in these conditions. Dr. Frejka drew attention to the frequency with which these pains occur in those engaged in heavy work. The majority are not from toxic infection, nor are they of the character associated with degenerative changes in the spine. Injury to lateral and articular processes and spondylolisthesis frequently play a part. Dr. Jaroš gave a comprehensive survey of the methods of diagnosing pain in this region, particularly with reference to the problem of industrial insurance.

Prof. Zahradníček demonstrated a new method of treatment for spondylolisthesis, in which a bone graft from the outer side of the iliac bone is introduced so as to give support to the body of the fifth lumbar vertebra. During the remainder of the session, papers on various subjects having particular orthopaedic interest were presented by a large number of the members.

The Congress then closed with a general assembly of the members of the Czechoslovakian Orthopaedic Society. At this meeting, Prof. Dr. Mikula of Bratislava was elected President and it was voted that the principal subject of the next Congress should be "Inflammation of the Joints". Prof. Frejka was elected as the principal speaker on the subject of "Conservative Treatment for Inflammation of the Joints". Members of the Jugoslavian Society undertook the report on gonorrhoeal inflammation and Prof. Mikula a report on arthroplasties. Prof. Zahradníček is to be the speaker on the subject "Treatment of Fracture of the Neck of the Femur".

The next Congress is to be held at Bratislava on June 27, 28, and 29, 1936.

Current Literature

MECHANICS OF NORMAL AND PATHOLOGICAL LOCOMOTION IN MAN. By Arthur Steindler, M.D., F.A.C.S. Springfield, Illinois, Charles C. Thomas, 1935. $8.00.

The book deals with an immensely complicated set of phenomena the study of which has interested scientifically minded students from very early times. The author labors under no delusions as to the difficulties in deducing something that is of practical, clinical importance from a mass of observations based upon studies in physics, mathematics, physiology, biochemistry, and mechanics.

In Part I, the approach to present-day kinesiological concepts is traced interestingly from the historical standpoint, leading up to a consideration of the relations of the science of human motion to other allied sciences. That the study is not a purely theoretical one is supported by the fact that there are many close analogies between what the mechanical engineer has determined in respect to strains and stresses when applied to inert materials and what the kinesiologist has ascertained. The importance of knowing of how much value skillful motion is as compared with unskillful motion is very great. The application of the laws of mechanics to human motion is fully discussed, the body being regarded as an inert unit, but in life it must be looked upon as an articulated, mechanical unit; in this respect, the only possible motion is rotary,—one part moving against another. This calls for a readjustment of the action of gravital laws for the maintenance of body equilibrium, a much more complicated mechanism than is required in the case of inert bodies. Suffice it to say that a formula has been worked out by which the resistance of a human limb to rotary motion may be accurately expressed in mathematical terms. The application of this formula makes it possible to appreciate certain peculiarities of the human gait and many other manifestations of human activity, such as running, jumping, and the like. After a consideration of the many graphic methods of recording the planes of the centers of gravity in the various joints and a discussion of the physical properties of bone, the author proceeds to a discussion of the dynamics of muscle action in response to which provision is made for shifting the axes of the muscles that are almost invariably arranged in parallelism with the axes of the parts of the skeleton which they are to move, so that the angle of the application of the force which they are to exert may be increased. Power and speed are recognized as distinguishing properties of muscles in different parts of the body where these qualities are particularly called for in the performance of their functions. The author then discusses the elasticity and contractility of muscle fibers and the tensile strength of tendons in their relation to the determination of the location of ruptures of these structures under adverse conditions. The first section closes with three chapters on "Electrophysical Analysis of Muscle Action", "The Coordination of Skeletal Muscle Action", in which simple lever action as a problem in mechanics must needs be modified in view of the manner in which such a simple mechanical principle undergoes modification when working against other joints, and "Fatigue and Recovery".

In Part II, specific application of the mechanical principles enunciated in the previous section is made to the vertebral column, the thorax and pelvis, the shoulder girdle, and the elbow and hand, in both normal and pathological conditions. The summation of all this is presented in an analysis of the activities of the baseball pitcher, the shot putter, the discus thrower, the broad jumper, and the track man, and finally in a study of the human gait. The studies are invaluable for the teacher of physical culture, as well as for the orthopaedic surgeon, the solution of whose problems will be made infinitely clearer when the reasons for normal behavior are understood. The author has succeeded admirably in translating abstruse and extremely technical mechanical data into practical application, understandable "to the man in the street".

DIE ORTHOPÄDISCHE WELTLITERATUR. Edited by Prof. Dr. August Blencke and Prof. Dr. Hermann Gocht. I. Band. Stuttgart, Ferdinand Enke, 1936. 87 marks.

This is the first of two volumes and is composed of references to works on orthopaedic surgery gathered from all over the world. This enormous piece of work has been issued under the direction of Prof. Dr. August Blencke, of Magdeburg, and Prof. Dr. Hermann Gocht, of Berlin. The need of such a volume was suggested by the compilation of world literature, published by Hoffa and Blencke in 1905. Since that time, references to the literature on orthopaedic surgery and many of its allied or associated departments in medicine and surgery have not been collected and made available to the medical world. The present volume presents the literature on this subject which has appeared throughout the world between 1905 and 1930. The compilation of this bibliography represents an immense amount of work on the part of the editors, their collaborators, and the publishers. The task was made more difficult by the fact that in some countries many of the allied subjects were grouped under orthopaedic surgery.

The book is very conveniently arranged, the references under each subject being indexed alphabetically according to the name of the author. Easy access to the literature during the last thirty years is afforded to orthopaedic surgeons, general surgeons, pediatricians, nerve specialists, anatomists, and pathologists. In selecting the material, the editors have taken the works which are of the most significance to orthopaedic surgery. Many subjects are not included, such as fresh fractures and dislocations, etc., but such conditions as malunited and ununited fractures and pseudarthroses, sequelae of bone inflammation, are included when they have a definite orthopaedic bearing.

The material is divided into six main headings:

1. The care of cripples, war injuries, general orthopaedic subjects, and works associated with these on anatomy, physiology, pathology, and diagnosis;

2. Orthopaedic apparatus, bandaging, and apparatus used in recumbency;

3. Closed and open surgery, including closed methods of treating deformities, operations on the soft parts, operations on the bones and joints, amputations, and artificial limbs;

4. Massage and gymnastics, including physiotherapy and exercises used in the treatment of orthopaedic conditions;

5. Congenital diseases and deformities.

6. Acquired diseases and deformities, including diseases of alteration of the skin, tendons and muscles; pathological changes in the central nervous system; infantile paralysis; injury to the peripheral nerves; diseases of bones and joints; diseases and deformities following injury to the bones; diseases and deformities subsequent to injury of the joints; rheumatism; bone and joint tuberculosis; rickets; and osteomalacia.

This first volume will be welcomed by all who have occasion to investigate the work which has been done and it will be indispensable to libraries and institutions.

ANATOMIA DELLA LUSSAZIONE CONGENITA DELL'ANCA (Anatomy of Congenital Dislocation of the Hip). By Prof. Dr. Vittorio Putti. Bologna, Licinio Cappelli, 1935. 300 lire.

In the first part of his newest publication, Prof. Putti gives a minute description of the anatomical findings in congenital dislocation of the hip, including the relations of muscles, nerves, the capsule, the secondary socket, the femoral epiphysis, and the neck of the femur. He emphasizes particularly the changes in the anatomical arrangement of the glutei and the iliopsoas, and the relation of the latter to the capsular isthmus. Then follows a description of the cotyloid and femoral insertions of the capsule, the round ligament, and the glenoid limbus. The latter's relation to the reduced head is of particular interest. The descriptions of the secondary socket and the femoral epiphysis and its separation from the cotyloid contour (*lateralizzazione*) in subluxations are classic. So also is the paragraph on anteversion, evaluating its pathological significance, etc. Especially valuable is the description of a specimen of a hip, six months after reduction, as it gives a clear insight into the processes of initial reconstruction. The richness of the proliferating, well vascularized connective tissue in all parts of the articulation is noted;

at the same time, this specimen illustrates the plastic adaptation of the newly reduced articulation to the new mechanical condition.

Then follow most excellent roentgenograms and mechanical drawings of the normal hip, the musculature of the dislocated hip, and the subluxated and dislocated hip in all stages, with splendid anatomical specimens showing every detail of muscular, capsular, and skeletal changes. There are nine observations on pathological specimens of unreduced hips and of the bloodless reduction. The technique of open reduction is beautifully illustrated. Variations of the acetabular inclination and the predislocation stage are demonstrated by roentgenograms. Also shown by excellent roentgenograms are subluxation and its evolution, infantile and juvenile dislocation, and inveterate dislocation. In the roentgenographic section, probably the most fascinating chapter is that on reconstruction and healing of the reduced hip; this chapter contains some rare instances of perfect anatomical restitution.

Last, but certainly not least, is a section on the postreduction pathology, showing degenerative changes in the epiphysis, necrosis, fragmentation, deformations of the head, etc.; and a most interesting series of pseudocongenital dislocations,—poliomyelitic, traumatic, pyogenic.

To say that this book is the best that has yet appeared on the subject is hardly doing it justice. It is a classic in every sense; a monument of most elaborate and painstaking study and a wonderful work of art.

LOCALIZED RAREFYING CONDITIONS OF BONE AS EXEMPLIFIED BY LEGG-PERTHES' DISEASE, OSGOOD-SCHLATTER'S DISEASE, KÜMMELL'S DISEASE AND RELATED CONDITIONS. By E. S. J. King, M.D., D. Sc., M.S. (Melb.), F.R.C.S. (Eng.), F.R.A.C.S. London, Edward Arnold & Co., 1935. 35 shillings. Baltimore, William Wood & Co., 1935. $7.50.

It is fortunate that we have at last in book form an exhaustive presentation of the diseases of the growth centers. The material contained in this book represents a tremendous task because of the necessity of reviewing a bibliography of almost 1,000 articles. The author is generous in quoting from the opinions of others, adding those of his own gathered from an exhaustive study of the subject. The various subjects are illustrated with well selected prints, the reproductions of which are good. A very complete bibliography is appended to each chapter.

The early chapters are concerned with a consideration of normal bone structure, development, chemical composition, physiology, and anatomy. Factors producing rarefaction of bone and excessive calcification are considered,—generalized diseases of growing bone, such as rickets, infantile scurvy, and syphilitic osteochondritis, as well as certain post-traumatic rarefying diseases occurring in adult bone.

The general term "osteochondritis juvenilis" is used to indicate the process in the various growth centers. The primary and secondary centers of ossification are enumerated. As the author indicates, the term "osteochondritis" is used with certain reservations, since pathological study of the disease has revealed no evidence of true inflammation.

During the last three decades, a disorder of the centers of ossification of a number of bones of the human skeleton has been described. It presents a characteristic roentgenographic appearance in the newly formed bone and it has been recognized by means of roentgenograms in all the various sites of occurrence.

As the author states, the investigation of the literature relating to this condition reveals a confusion and plethora of terminology that is almost unrivalled in medical literature. Further, it discloses a wealth of hypotheses, embracing many views from simple deductions based on experimental or clinical inquiry to purely philosophical considerations lacking a basis of observation, and a rapidly extending bibliography including many papers which add little or nothing to our knowledge. On the other hand, a large amount of accurate clinical knowledge has accumulated, and information concerning the pathological changes has been obtained from the study of material removed at operation.

As a whole, the book is well balanced and informative. The author is to be commended for the thoroughness and fairness with which he has presented the subject. The book should be read by all those interested in diseases of bone.

DER SCHENKELHALSBRUCH; EIN MECHANISCHES PROBLEM (Fracture of the Neck of the Femur; a Mechanical Problem). By Dr. Friedrick Pauwels. Beilageheft zur Zeitschrift für Orthopädische Chirurgie, LXIII, 1935. Stuttgart, Ferdinand Enke, 1935. 15 marks.

The late Alfred Schanz, to whom this important monograph is dedicated, studied the mechanics of the high and low subtrochanteric osteotomies. His simple explanation and dramatic proof of their effectiveness in reducing disability at the hip have stimulated the use and further investigation of these measures. One of his pupils now offers a most exhaustive and significant study of the problem of fractures of the femoral neck.

Two-thirds of the volume deals with the clinical aspects. The mechanical forces which influence callus formation are considered in general and with specific relation to the femoral neck. The effects of stress and strain are clearly differentiated. The most important forces which operate are shear and pressure. If the plane of the fracture is vertical, the shear is maximal. As the fracture nears the horizontal, the direct pressure on the fragments becomes greater and the shearing force less. The elaboration of this fact leads to the classification of femoral-neck fractures as those in which (1) the shear is negligible (valgus position), (2) the pressure component is insignificant as compared to the shear, and (3) the line of force on the head passes medial to any point of contact of the fractured surfaces, so that there is not only a shearing but also a tilting force. The latter results in strain rather than stress on most of the forming callus.

The obvious relation of these observations to prognosis and treatment is followed out with great exactitude.

Various methods of treatment of fresh and ununited fractures are reviewed and dispassionately evaluated as a preliminary to the recommendation of high subtrochanteric osteotomy (renamed *Reklination*) as the ideal treatment of pseudarthrosis. The mechanical principles are illustrated by simple diagrams and photographs of working models. Case records and characteristic reproductions of roentgenograms are accompanied by outline diagrams in which forces are analyzed.

The last fifty pages are so highly mathematical that they will be skipped by most medical readers. Several formulae are derived which explain in a striking manner the progress of healing or non-union of the various types of fractures of the femoral neck.

In this period of argument over the efficacy of this screw or that nail, it is refreshing to get back to fundamentals of treatment. No contribution to our understanding of the "Unsolved Fracture" is more significant than the work of Dr. Pauwels, which is here so completely presented.

RUSSELL A. HIBBS, PIONEER IN ORTHOPEDIC SURGERY. By George M. Goodwin. New York, Columbia University Press, 1935. $2.00.

From those who were privileged to know Russell Hibbs, this appreciation of him as an individual and as a surgeon will receive a hearty welcome. Very properly, Mr. Goodwin has emphasized Hibbs's most outstanding quality—his personality. The charm of a southern gentleman made a friend of whomsoever he met, with but few exceptions. This charm, coupled with his native ability as a technician and his deserved popularity among those who worked with him, enabled him to achieve the prominent position which he gained as an orthopaedic surgeon. His realization of the difficulties of providing sufficient hospitalization facilities for those who needed them and were too poor to pay for them supplied the incentive for finding a method of treatment that would shorten the duration of hospital care for this class of patients and by so doing bring a larger number within reach of the service they needed. To have done this was a major surgical and economic contribution. Such a record of accomplishment by an unaccredited young

man who made his way, at first on sheer personality, to an enviable position in a great city, where competition was keen, should be made available for the encouragement of others.

ERBBIOLOGIE DER ANGEBORENEN KÖRPERFEHLER (Biological Inheritance of Congenital Deformities). By Prof. Dr. Max Lange. Stuttgart, Ferdinand Enke, 1935. 9.60 marks.

In this handbook, the author estimates that there are in Germany 100,000 persons with congenital bodily deformities, the care of whom the State should undertake. The State demands, however, that the deformed group be prevented from multiplying. The author agrees with Rüdin that, by curing many of these patients, modern orthopaedic surgery often removes an obstacle to marriage. Progressively the burden of the State is augmented and there is developed an increased percentage of congenitally deformed patients.

The book deals with the problems connected with the law for sterilization, passed on July 14, 1933. The author states that to come under the law a deformity must be severe and the probability of inheritance must be high. The correctability of a lesion is not a decisive factor.

The author of this book, in company with the authors of several other recent publications, wrestles bravely with the medico-legal judgments involved. He describes the conditions which are connected with this problem and discusses some of the special deformities which come within the domain of orthopaedic surgery, such as club-foot, club-hand, and congenital pes cavus. He then considers systematically the various orthopaedic deformities and their legal fates,—a list worthy of serious study.

To the average physician, if eugenically minded, the enormous problems involved in the individual decisions appear almost impossible of solution, considering our present knowledge, but the book is distinctly interesting in relation to its medico-legal aspects. The author, however, is obliged to help the local medical board reach a definite conclusion in each case and usually manages to be quite explicit, although frequently not quite medically convincing.

BALANCE SKILLS IN PHYSICAL EDUCATION. By Charles Leroy Lowman, M.D., F.A.C.S. Ann Arbor, Edwards Brothers, Inc., 1935. $1.60.

The author of this work elaborates on the necessity of more accurate coordination in the use of physical exercises, which is usually not sufficiently emphasized. In the development of his system, Dr. Lowman has given full recognition to this need of coordination and has employed it in his own individual work for many years. In this book he explains the system of balance exercises which he has used.

The first part of the book is devoted to a consideration of the anatomical, physiological, and neuromuscular factors, and the various theories which have been offered in explanation of the mechanism of balance.

A portion of the book is then given to an exposition of the use of the tilted board in developing balance control and in adding to coordination, and the effects of this training on the different parts and structures of the body. Dr. Lowman has studied the question of the physical stress of malposture in its relation to the added strain from imbalance. He then makes a number of suggestions in regard to the use of the tilted board in the various exercises and its employment by field workers. He gives also the contra-indications for its use in certain conditions and diseases and describes the various exercises which are employed to correct the malposture and the imbalance, with prescriptions for their special use.

The text is supplemented by a number of excellent illustrations, and, for all who are interested in the use and effects of physical training, especially as applied to orthopaedic conditions, this book will be found to contain many helpful suggestions and will be of very practical value.

DIE VERLETZUNGEN DER WIRBELSÄULE (Injuries of the Spinal Column). By Prof. Dr. V. Schmieden and Dr. L. Mahler. (*In* Vorträge aus der praktischen Chirurgie, 2. Heft, Herausgegeben von Erich Lexer.) Stuttgart, Ferdinand Enke, 1935. 1.60 marks.

The authors have evidently been impressed by the astounding increase during recent years of injuries to the spinal column. Because of the diversity of these injuries, many new problems have arisen, necessitating further study.

The authors have presented this subject from many points of view and have considered practically all the conditions which result from injuries to the spinal column and its appendages. They find that the largest number of injuries occur in the thoracic and lumbar regions, particularly at their junction. Two-thirds of the injuries involve the first lumbar vertebra; next in frequency are injuries to the twelfth dorsal vertebra; and, third, injuries to the second lumbar vertebra. Hospitalization is most advisable, since it lessens the unfavorable sequelae.

From the standpoint of treatment, fractures are divided into four groups: (1) compression fractures of the vertebral body; (2) diagonal fractures, with anterior wedge-shaped fragmentation; (3) partial-dislocation fractures; and (4) complete-dislocation fractures, with absolute dissolution of continuity.

In compression and diagonal fractures, the posterior longitudinal ligament in the canal remains intact, which is a particularly important feature, inasmuch as it protects the cord anteriorly. In the types of dislocation-fractures considered under the last two headings, tearing of this ligament occurs and the cord is usually crushed. In the treatment of compression and diagonal fractures, the authors recommend immobilization by recumbency in plaster. Rarely does consolidation fail to occur, but in that event operation may be necessary to overcome this static insufficiency.

The problem of cord injuries and their treatment is then discussed in detail; in general, the authors take a conservative attitude on this question. Lumbar puncture is frequently an aid in determining the condition of the cord and the myelograph is also of value in early diagnosis, as it helps to establish the prognosis and to indicate the feasibility of operation when paralysis exists.

The authors then consider the various types of injuries which are found in this region, including and discussing in order fractures of the transverse and spinous processes, fractures of the sacrum, fractures of the coccyx, and dislocations, which are too often regarded as sprains, but which are very often accompanied by fractures, particularly in the dorsal region. The authors then take up the question of violence to the spinal column without actual fracture, but with damage to the ligamentous and muscular apparatus. They discuss spondylolisthesis, as well as spondylitis deformans and the rôle which it may play in injuries of the spine. The question of gunshot and stab wounds is also considered.

This subject of spinal injuries presents many new factors and, as a decidedly controversial field, it offers many opportunities for expression. Unfortunately, the spine still remains the dumping-ground for vague and indefinite diagnoses which are the source of many doubtful undertakings and much keen debate. Out of all the chaos there are constantly developing many valuable observations which may be of benefit to the physician in the treatment of his patients.

INDIVIDUAL EXERCISES. SELECTED EXERCISES FOR INDIVIDUAL CONDITIONS. By George T. Stafford, M.S., Harry B. DeCook, M.A., and Joseph L. Picard, M.S. New York, A. S. Barnes and Company, Incorporated, 1935. $1.00.

There is a definite need for a guide in the selection and the carrying out of special exercises for individual cases, which may be used by physicians, teachers, and physical trainers. The three authors of this book have had a great deal of experience in this department of physical training, and have drawn on their practical knowledge in compiling a series of exercises which may be used in dealing with the various malconditions which constantly need attention.

The book contains excellent advice in regard to the general subject of exercises and the purposes for which they are designed, and will be distinctly valuable to those who desire help on this problem. The authors discuss the part which exercises play in maintaining health and in preventing certain conditions. Specific exercises are explained and illustrated by "stick men" drawings, their purposes are indicated, and the factors influencing their choice for use in the simpler conditions are given. The authors state very distinctly that these exercises should not be given except by advice of a physician. After such advice is received, a selection can be made by referring to the grouping which is given in this book.

The information in this book is particularly useful to teachers who are obliged to supervise the exercises of children and to those physicians who have not had opportunity to become familiar with the exercises for the special conditions for which they may be called upon to prescribe. The well equipped physical trainer would find this book interesting, but he should already be familiar with most of the material which it contains.

ORTHOPÄDIE VOR 100 JAHREN. DIE ORTHOPÄDISCHEN INSTITUTE ALS VORLÄUFER DER HEUTIGEN KRÜPPELHEIME (Orthopaedic Surgery 100 Years Ago. The Orthopaedic Institution as a Predecessor of the Present-Day Home for Crippled Children). By Prof. Dr. B. Valentin. Stuttgart, Ferdinand Enke, 1935. 1.80 marks.

This readable description of the early orthopaedic institutions of Germany and France is illustrated by several cuts of men, buildings, and apparatus. It deals chiefly with the period when club feet and scoliosis were the only deformities treated. The leaflet furnishes chiefly a background for understanding the government organization for the care of the crippled in Germany. It is interesting reading and valuable history.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), II, Núms. 16–18, 1935.
Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núms. 18, 19, 1935.
Archivio di Chirurgia Infantile, I, Fasc. 4, 1935.
Cleveland Clinic Quarterly, II, No. 4, 1935.
Current Medicine, II, No. 12, 1935.
The Mississippi Doctor, XIII, No. 6, 1935.

VERTEBRA PLANA-CALVÉ. Halfdan Sundt. *Acta Chirurg. Scandinavica*, LXXVI, 501, 1935.

The author reports a case which he has observed for one year, and describes a case from the literature which has just been followed up after a lapse of eleven years. Flattening progressed in spite of a plaster jacket or bed rest. Only slight regeneration of the vertebral body was noted. The subject is thoroughly discussed and a critical survey of the literature is included.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

TUBERKULOSE IN DEN DIAPHYSEN DER LANGEN RÖHRENKNOCHEN (Tuberculosis of the Diaphysis of the Long Bones). Ragnar Magnusson. *Acta Orthop. Scandinavica*, VI, 93, 1935.

Thirty cases of diaphyseal tuberculosis in twenty-three patients are critically analyzed and the findings tabulated. They comprise 1.08 per cent. of the cases of bone tuberculosis in the *Apelviken Kustsanatoriet* over a period of six years. The lesions are designated as metaphyseal, periosteal, osseous, and osteomyelitic, but the distinction is not always clear cut. The statistics in regard to the localization of foci are as follows: femur, in nine cases; tibia, in eight; radius, in five; ulna, in four; fibula, in three; and humerus, in one.

Metaphyseal lesions were usually associated with joint symptoms, which were relieved by early operation in four cases and by conservative treatment in five. The symptoms were obviously toxic in nature. Early operation is advised if there is the least evidence of progress of the lesion.

Eight cases of periosteal tuberculosis were treated conservatively. Five cases of osteitis and seven of osteomyelitis completed the list. Subperiosteal resection was performed in three of the latter cases, with satisfactory regeneration of bone from the periosteum.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

NECROSIS CAPITIS FEMORIS. Kurt Stenport. *Acta Orthop. Scandinavica*, VI, 127, 1935.

The closed reduction of slipped femoral epiphyses has led to necrosis of the head and even bony ankylosis in so many cases in Swedish hospitals that this treatment is condemned. Instead, for the mild recent cases, the writer suggests simple traction with internal rotation for three months, and then crutches for three months more. For the cases in which there is considerable displacement, operative correction is recommended.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

BESTEHT EIN ZUSAMMENHANG ZWISCHEN HALLUX RIGIDUS UND DEN OSSALEN ASEPTISCHEN NEKROSEN (Are Hallux Rigidus and the Aseptic Bone Necroses Related?). S. Ribbing. *Acta Orthop. Scandinavica*, VI, 138, 1935.

In support of the theory that hallux rigidus is caused primarily by aseptic bone necrosis, a detailed study is made of a family of seventeen, who showed multiple bone lesions of the aseptic-necrosis type. Four of this number had contractures of the great toe joint with suggestive roentgenographic findings.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

VERTEBRA PLANA CALVÉ. Nils Lindström. *Acta Orthop. Scandinavica*, VI, 208, 1935.

A case of true vertebra plana of Calvé is followed for seven years, after onset at the age of four years.

The second lumbar vertebra gradually became flat and dense during the first year. Then it gradually regenerated to about three-fourths of its normal height and normal bone structure. The case satisfies Calvé's postulates:

1. One vertebra only is flattened;
2. The intervertebral spaces are intact;
3. There is even an increase in thickness of the cartilage;
4. The vertebral rest yields a dense shadow on x-ray;
5. Regeneration takes place.

The writer is critical of the inclusion of several of the twenty-four cases in the literature which are classified as Calvé's disease.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

EL TRATAMIENTO DEL PIE BOT VARO EQUINO CONGÉNITO (The Treatment of Congenital Inverted Club-Foot). Barboza Vianna. *Cir. Ortop. y Traumatol.*, III, 141, 1935.

In this article, Dr. Vianna gives the results of a study of the principal causes of club-foot, including a review of the methods of treatment up to the present time, as well as those which are used by him in the Hospital San Francisco de Asís, in Rio de Janeiro.

His treatment in general depends somewhat on the age of the individual, and is outlined as follows: (1) from birth to the age of three years, manual correction; (2) from three to eight years, surgical treatment of the soft parts; and (3) after eight years, surgical treatment according to the deformity of the tarsus.

After discussing the various surgical methods, including those of Phelps, Kirmisson, Ombrédanne, Farabeuf, Nové-Josserand, Albee, etc., Dr. Vianna describes his method of treating bilateral congenital inverted club-foot by a single operation. If one of the inverted club feet shows greater deformity than the other, he performs the wedge-shaped dorsal tarsectomy of Farabeuf, modified to apply to the individual case. On the other foot he performs a tarsectomy according to the method of Phelps and Kirmisson. He then introduces a bone wedge extracted from the tarsus of the other foot. In this way, the two operations can be done at the same time.

The author reports good results in eight of his own cases, one of which has been followed up for three years. In one of the cases, the graft was eliminated without any undue disturbance.

The other surgical methods are not eliminated from his hospital; this procedure is added to the list of operations which are employed.

Evolutión clínica de los injertos óseos (Clinical Evolution of Bone Grafts). Alberto Inclán. *Cir. Ortop. y Traumatol.*, III, 161, 1935.

After studying the clinical development of the bone graft in some hundreds of cases, Dr. Inclán gives his opinion with reference to the total or partial vitality of the bone graft, stating that the fate of such a graft depends on the biological purposes for which it is used and where it is implanted. When these purposes have been accomplished, the graft as such disappears and is replaced by newly formed bone which varies in structure according to the physiological demands of statics and dynamics, governed by the laws of Wolff. He states that the bone graft must first become united to the bone and must keep its integrity until the changes which result from its presence have been completely accomplished.

The author then presents a clinical and roentgenographic study of the development of bone grafts in cases of delayed union and pseudarthrosis of fractures, fixation of tuberculous joints, fusion of the spine, stabilization of joints, etc. From this study, the following conclusions are drawn:

1. When a bone graft is employed for fixation of a fracture in a case of delayed union, the graft will disappear after union is complete.
2. When a bone graft is used for fixation of a fracture and in order to fill the gap between the fragments, the graft changes in structure until it attains the size and shape necessary to compensate for the deficiency.
3. If a bone graft is used for extra-articular arthrodesis of the joints, the integrity of the graft is indispensable and should be maintained until the lesion is healed. Progression of the lesion without protection of the bone graft may produce loss of integrity of the graft.
4. When a bone graft is used for stabilizing dislocated or relaxed joints, the structure will change according to the rôle which it is to play. If its purpose is not accomplished, the graft will disappear either partly or entirely.
5. When a bone graft is employed with the object of replacing a large portion of bone, its fixation and osteotrophic action depends upon complete preservation of the graft until the newly formed bone takes on the normal structure; then the bone graft will disappear entirely.

Ochronose und Unfall (Ochronosis and Accident). Otto Diebold. *Deutsche Ztschr. f. Chir.*, CCXLV, 63, 1935.

Ochronosis often leads to very marked joint changes, the so called chondrosis dissecans ochronotica. The intervertebral discs, like the cartilages of the joints and ribs, contain dark pigment. They degenerate and become calcified, and an ankylosing process takes place, which does not lead to the formation of spurs and bony bridges. These changes are different from those of hypertrophic arthritis. The involvement of the skeleton represents the most severe type of ochronosis.—*Ernst Freund, M.D., Iowa City, Iowa.*

Störungen im Heilverkauf aseptischer Kniegelenkoperationen mit und ohne infektiöse Grundlage (Complications in the Postoperative Course of Aseptic Arthrotomies of the Knee with and without an Infectious Basis). Karl-Heinz Magoley. *Deutsche Ztschr. f. Chir.*, CCXLV, 115, 1935.

One hundred and twelve aseptic arthrotomies of the knee joint, performed during a period of five years, are reviewed, with special reference to the postoperative course.

In two cases, thrombophlebitis of the saphenous veins occurred. Both patients were young and the thrombosis subsided with rest in bed. In two cases bronchitis developed and in two, sore throats. In seven cases, there was increased irritability of the knee joint. It seems that knees with lesions of the semilunar cartilages are especially

hypersensitive. In cases of removal of the menisci, if portions of the joint surface were smoothed (chondromalacia of the patella), the temperature did not return to normal before the tenth postoperative day, whereas in simple cases, the temperature was normal on the sixth day after operation. Necrosis of wound edges was present in two cases. Hematoma is a relatively frequent complication; it was observed in seven cases, in two of which infection occurred. In four cases, there were smaller subcutaneous hematomata which had to be opened. In each case, the temperature came down promptly after evacuation of the hematoma. In one case, subsequent examination of the wound revealed a spreading artery. In three cases, some mild infection occurred along the stitches; and, in two, a true infection of the incision developed. One case of infection, with formation of an abscess, was probably due to the operation. All of the other cases represent postoperative complications.—*Ernst Freund, M.D., Iowa City, Iowa.*

Über eine bemerkenswerte Form und Lokalisation neurogener Gelenkaffektionen (Unusual Forms and Localizations of Neurogenic Joint Affections). F. Rückart. *Monatschr. f. Unfallheilk.*, XLII, 131, 1935.

The author reports the case of a miner, thirty-seven years of age, who for the last ten years had suffered definite traumata to his hand and both feet, and who had developed aseptic necrosis, similar to that seen in Kienböck's and Köhler's diseases. A thorough neurological examination revealed syringomyelia. The author states that neurogenic joint affections may give a similar picture or may even resemble the typical course and symptoms of epiphyseonecrosis. In such cases, a thorough and careful neurological examination is always advisable.—*T. M. Pich, M.D., Iowa City, Iowa.*

Radiologic Study of the Development of the Spine and Pathologic Changes of the Intervertebral Disc. P. H. Malcolmson. *Radiology*, XXV, 98, July 1935.

This article describes the development of the intervertebral disc, and its structure. The disc is likened to a rudimentary joint,—the cartilaginous end plates are comparable to the articular cartilages; the annulus fibrosus, to the fibrosis capsule; and the nucleus pulposus, to the joint cavity. The adult disc contains neither blood vessels nor nerves, its nutrition being supplied by lymph.

The function of the disc is to transmit forces from one vertebral body to another and on it depends the axis of motion of the spine. The nucleus pulposus is under considerable tension and bulges out when the annulus fibrosus is ruptured or cut. Any condition which allows leakage of the nuclear material results in partial or complete destruction of the disc. The vertebral bodies then rub together, causing sclerosis, osteo-arthritis, and lipping. In scoliosis, the nucleus pulposus may shift laterally toward the convexity of the curve; this may explain the great difficulty in obtaining correction.

Accompanying old age or following trauma, fibrous tissue infiltrates the disc. Complete ossification may occur. Congenital defects or weakening of the cartilaginous plates from vertebral disease may permit prolapse of the nucleus pulposus thus producing smooth excavations in the vertebral bodies. Schmorl found varying degrees of prolapse in 38 per cent. of the cases in which routine spinal autopsies were performed.—*Edward N. Reed, M.D., Santa Monica, California.*

A Report on Application of Smith-Petersen Nail in Fresh Fractures of the Femoral Neck by Adaption of a Simplified Technic. W. B. Carrell. *Southern Med. J.*, XXVIII, 583, July 1935.

The author believes that exposure of the hip joint is not necessary. Interposition of soft tissue at the site of fracture is negligible if reduction is satisfactory. Drilling the neck aids circulation. Impaction is important. The procedure is as follows:

1. The fracture is reduced by manipulation (Leadbetter method) under local or general anaesthesia.
2. Anteroposterior and lateral roentgenograms are taken.
3. An incision is made over the greater trochanter and a stainless-steel drill, one-

sixteenth of an inch in diameter, is inserted through the trochanter, neck, and head into the acetabulum.

4. Roentgenograms are again taken.
5. A Smith-Petersen nail of the proper size is threaded over the drill and driven in.
6. Firm impaction is made.
7. Two or three additional drill holes are made through the trochanter, neck, and head.
8. Protection during convalescence is provided by plaster leg supports. Two cross bars control abduction and rotation. The splints are bivalved after three weeks, but are worn for about six weeks. The use of a wheel chair is allowed after four weeks. Eight weeks after operation a walking caliper is used until union is firm, from six to eighteen months. The nail may be removed if desired.

This paper contains a report of eight cases in which the method was used successfully, and is accompanied by a number of good illustrations.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE MANAGEMENT OF ATROPHIC ARTHRITIS. W. P. Holbrook and D. F. Hill. *Southern Med. J.*, XXVIII, 625, July 1935.

The authors have presented a brief discussion of atrophic arthritis with a typical case history, showing the variations in treatment during the different phases of the disease. In concluding, the author states: "In spite of the absence of a specific etiological agent or a specific cure for the disease, the wide-spread pessimistic attitude regarding treatment is not warranted. A thorough understanding with the patient and an approach to his problem as a constitutional disease will prevent deformity and restore the great majority of these unhappy people to a useful life."—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

NON-SUPPURATIVE OSTEOMYELITIS. DIAGNOSIS AND X-RAY TREATMENT. J. T. Murphy. *Southern Med. J.*, XXVIII, 679, Aug. 1935.

Five cases of non-suppurative osteomyelitis are presented, as follows:

Case 1. Sclerosing osteomyelitis of the Garrè type, treated by incision and curettage. The patient has been free from symptoms for eight years.

Case 2. Large area of bone destruction and new bone formation in the lower portion of the upper third and the entire middle third of the shaft of the tibia, treated by irradiation. The patient has been symptom-free for eight years.

Case 3. Expanding lesion of the clavicle, treated by irradiation. Thirteen months after the institution of roentgenotherapy, the patient was symptom-free.

Case 4. Destructive lesion of the outer portion of the cortex of the lower third of the femur, treated by irradiation. The patient was well eight months later.

Case 5. Expansile tumor of the lower portion of the radius, treated by irradiation. A year later, the bone was almost normal.

From a study of these cases the authors draw the following conclusions:

1. There are several types of non-suppurative osteomyelitis.
2. The pathology of these different types is essentially the same.
3. The presence of giant cells should not always lead to a diagnosis of giant-cell tumor.
4. The differential diagnosis between these lesions and a malignant process is not easy.
5. Some cases of non-suppurative osteomyelitis respond well to irradiation.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

FUNKTIONELLE NACHBEHANDLUNG NACH KNIEGELENKSOPERATIONEN (The Functional After-Treatment Following Operations on the Knee Joint). Hans Kraus. *Wiener klin. Wchnschr.*, XLVIII, 548, 1935.

The author points out that poor results may follow ideal anatomical results, due to

failure to prevent muscle atrophy and contracture. These conditions are due to postoperative fixation in which the same state of tension is maintained over long periods. Minimal tone is the objective. Postoperative irritation of the joint results in further trauma and inflammatory response. There is excessive postoperative strain. These changes follow in sequence as a rule. The atrophic muscle is easily overstrained.

The therapy is mobilization through active use of the shortened muscle, strengthening of the muscles, and protection of the extremity from overexertion. The mobilization is obtained by the isometric contraction of the muscle groups,—that is, diminution of tension is produced by the active work of the antagonists, even if no visible motor effect results. Graded exercises are used to strengthen the muscles. The usual physical therapy agents are also used. The exercises are divided into two groups, those with and those without a load.

The author describes two types of limps following operations on the knee,—that due to habit, and that due to real joint disability. The differential diagnosis of these is discussed.

During fixation, exercise should prevent atrophy of all the leg muscles except the vastus medialis. Various exercises are described in the article.

The treatment following operation on the menisci is discussed in detail. Heat and massage are not given, as they increase the swelling and effusion. Those patients treated with exercise alone were back at work in one month. In those cases in which heat and massage were used, the patients did not return to work for three months or longer.

Because of their recurrent nature, cruciate-ligament injuries are treated conservatively.—*Albert R. Smith, M.D., Iowa City, Iowa.*